A330 RR Trent 700
TECHNICAL TRAINING MANUAL
MECHANICAL & AVIONICS COURSE - T1+T2 (LVL 2&3)
APU

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APU

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MAINTENANCE PRACTICE

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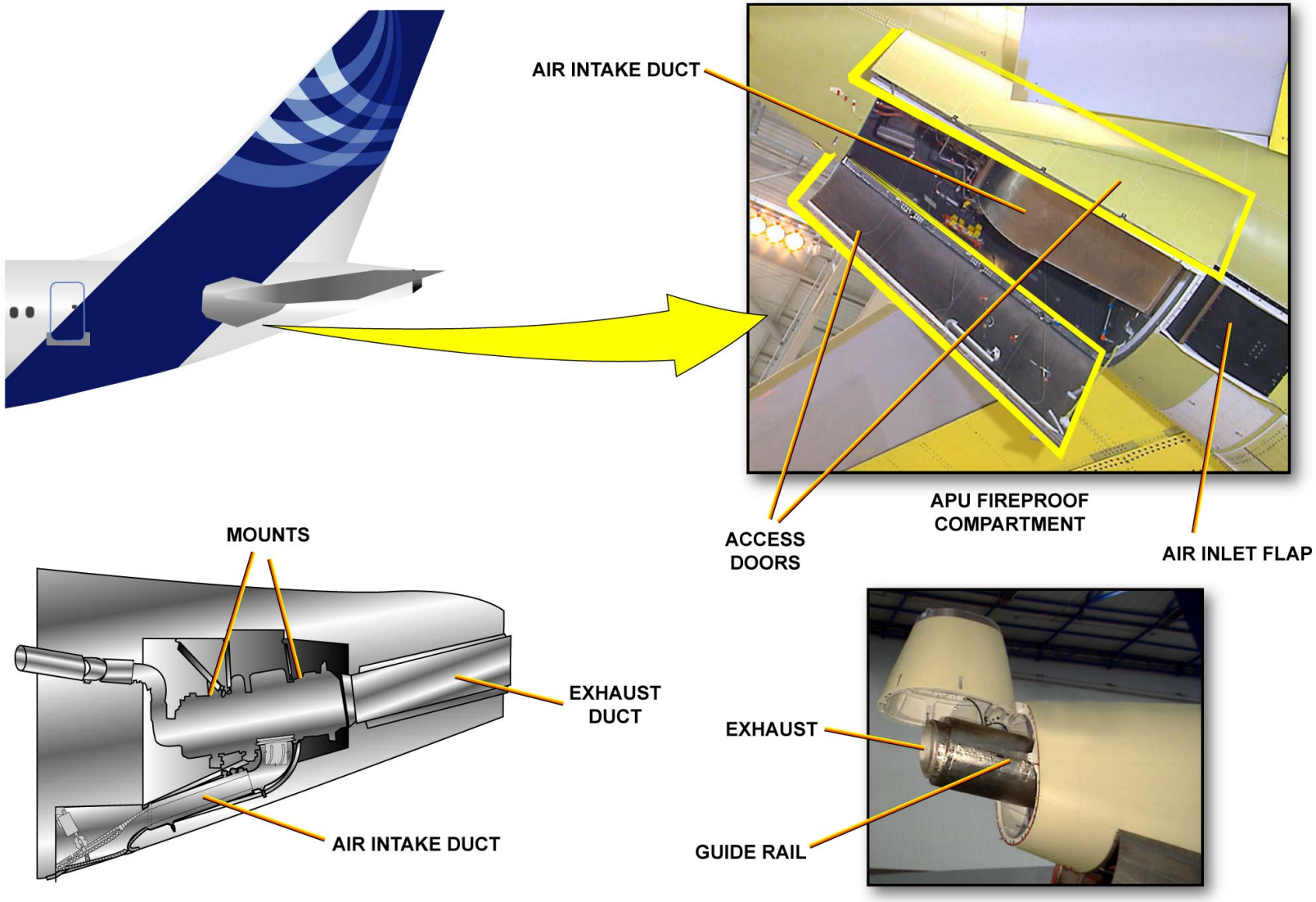
GCL13151 - GEHT0M0

APU SYSTEM COMPONENT LOCATION (2)

INSTALLATION

General view of APU components.

GCL13151 - GEHT0M0 - FM49C2COMPLOC01



INSTALLATION

APU SYSTEM COMPONENT LOCATION (2)

ENGINE

Presentation of APU components.

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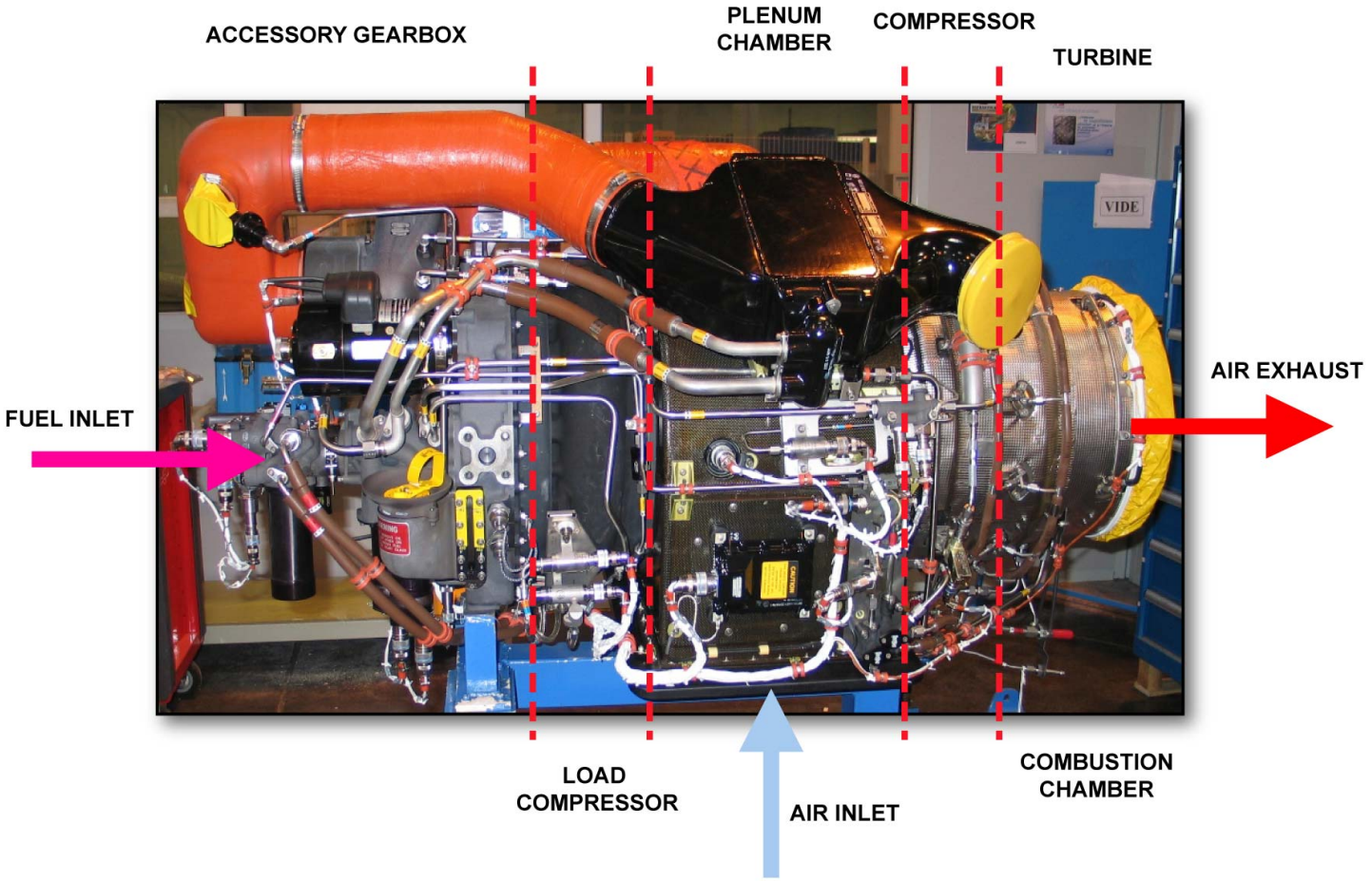
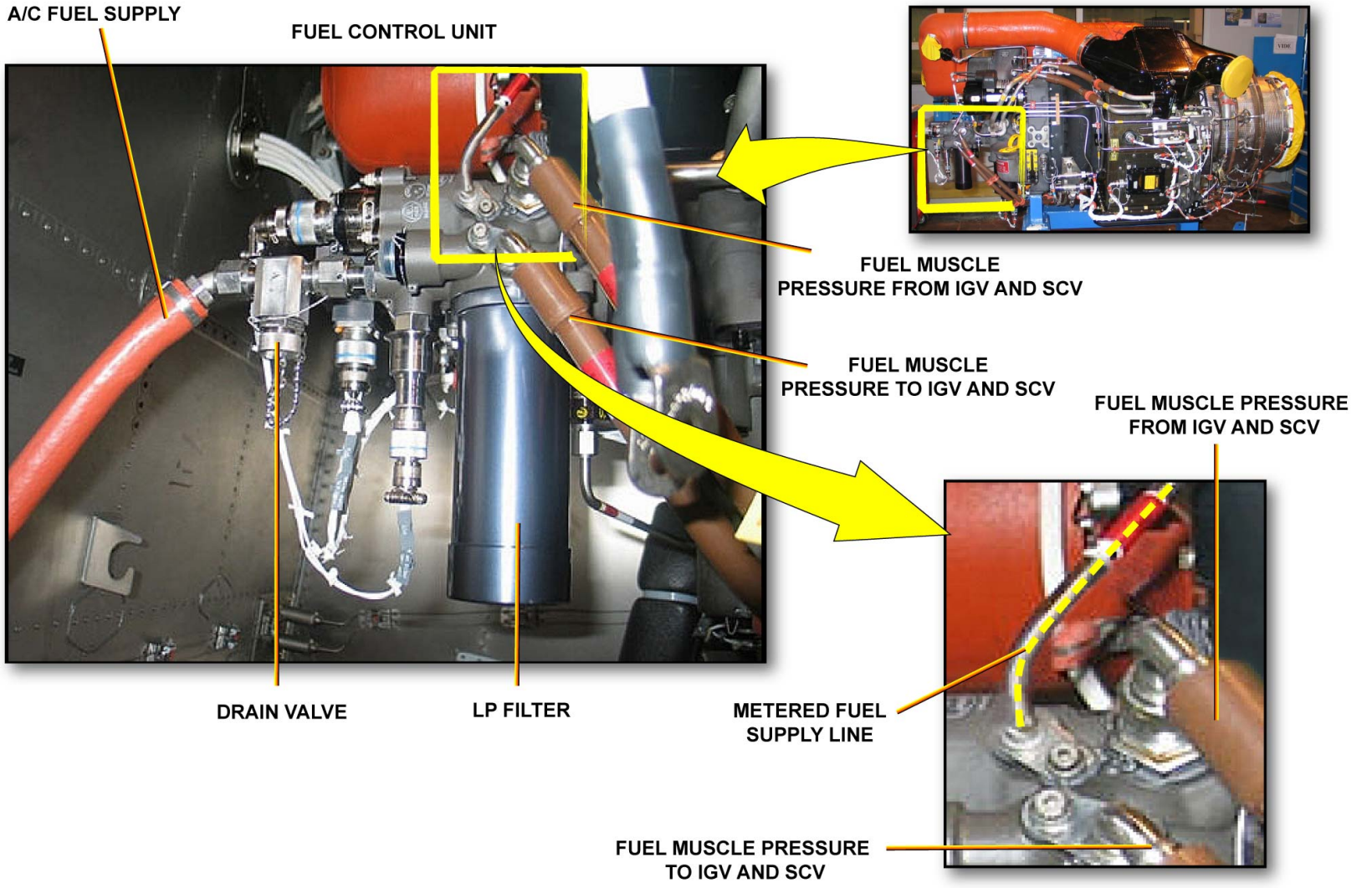

ACCESSORY GEARBOX
PLENUM CHAMBER
COMPRESSOR
TURBINE
FUEL INLET
AIR EXHAUST
LOAD COMPRESSOR
AIR INLET
COMBUSTION CHAMBER

ENGINE

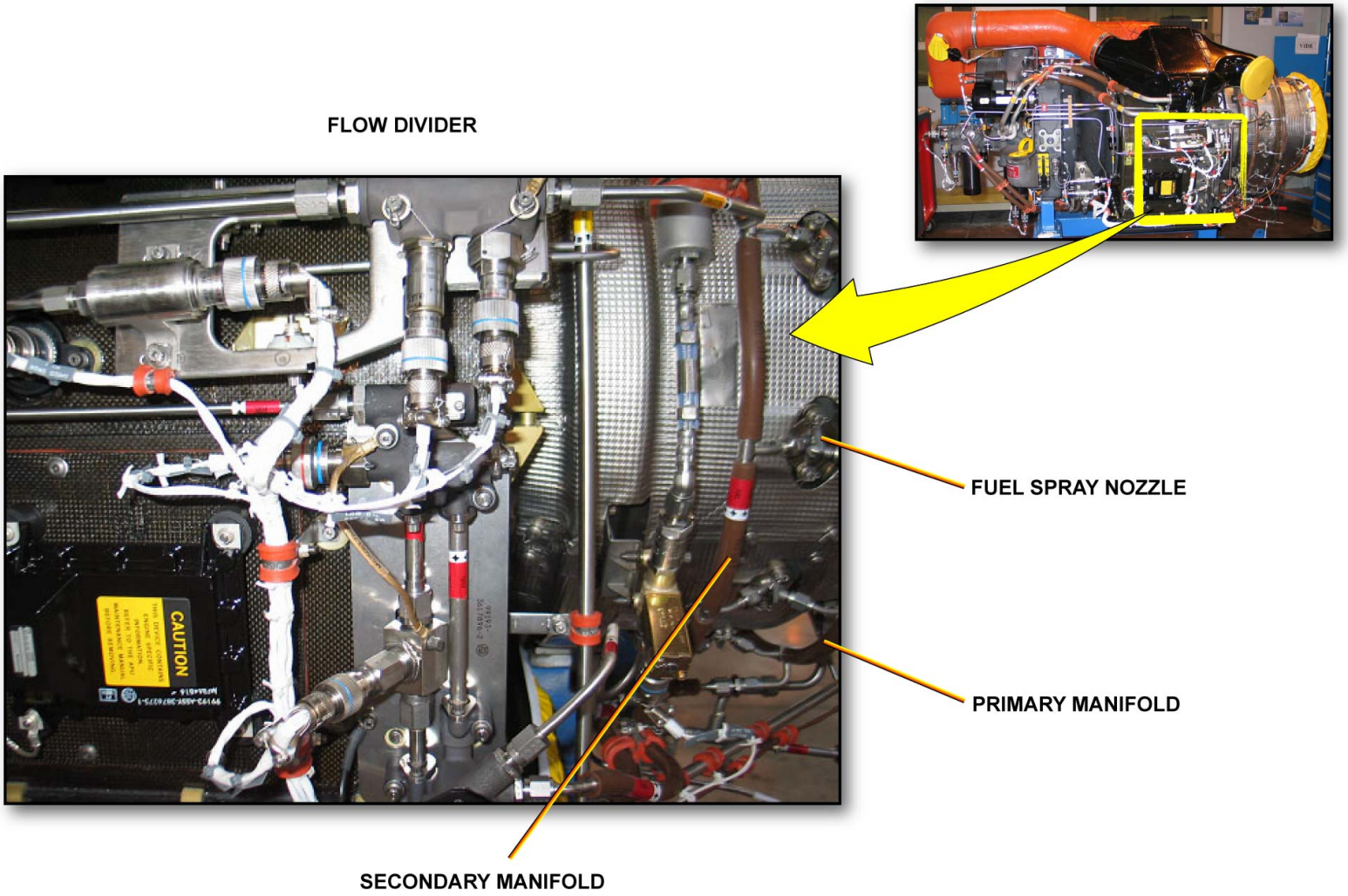
APU SYSTEM COMPONENT LOCATION (2)

FUEL

The APU fuel control unit includes a fuel supply line, a fuel muscle pressure to IGV and SCV, an LP filter and a drain valve.
The flow is divided in two parts: the primary fuel flow and the secondary fuel flow which is spread into the combustion chamber through the fuel spray nozzle.


A/C FUEL SUPPLY
FUEL CONTROL UNIT
FUEL MUSCLE
PRESSURE FROM IGV AND SCV
FUEL MUSCLE
PRESSURE TO IGV AND SCV
FUEL MUSCLE PRESSURE
FROM IGV AND SCV
DRAIN VALVE
LP FILTER
METERED FUEL
SUPPLY LINE
FUEL MUSCLE PRESSURE
TO IGV AND SCV

FUEL


FLOW DIVIDER
FUEL SPRAY NOZZLE
PRIMARY MANIFOLD
SECONDARY MANIFOLD
CAUTION

FUEL

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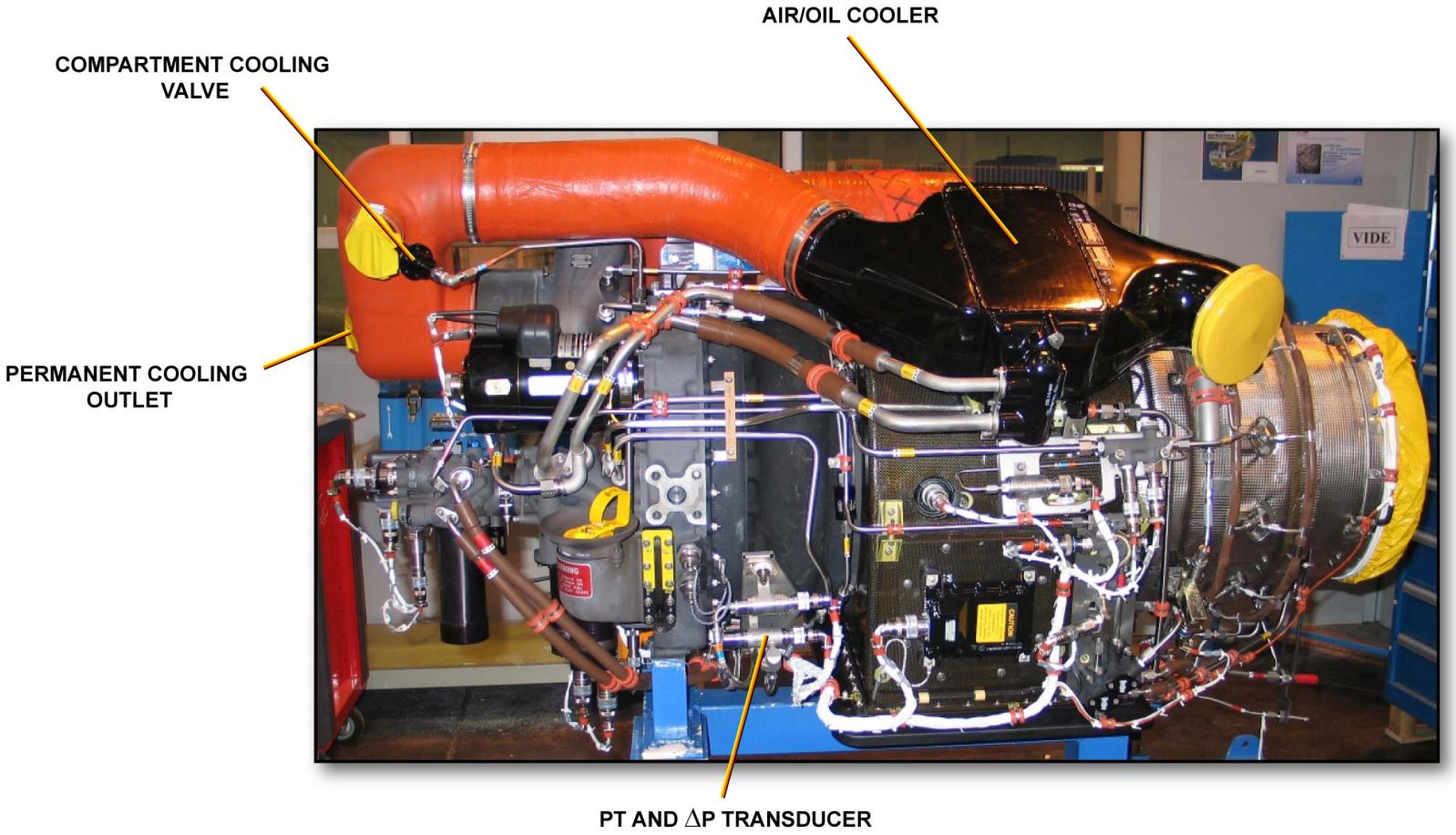
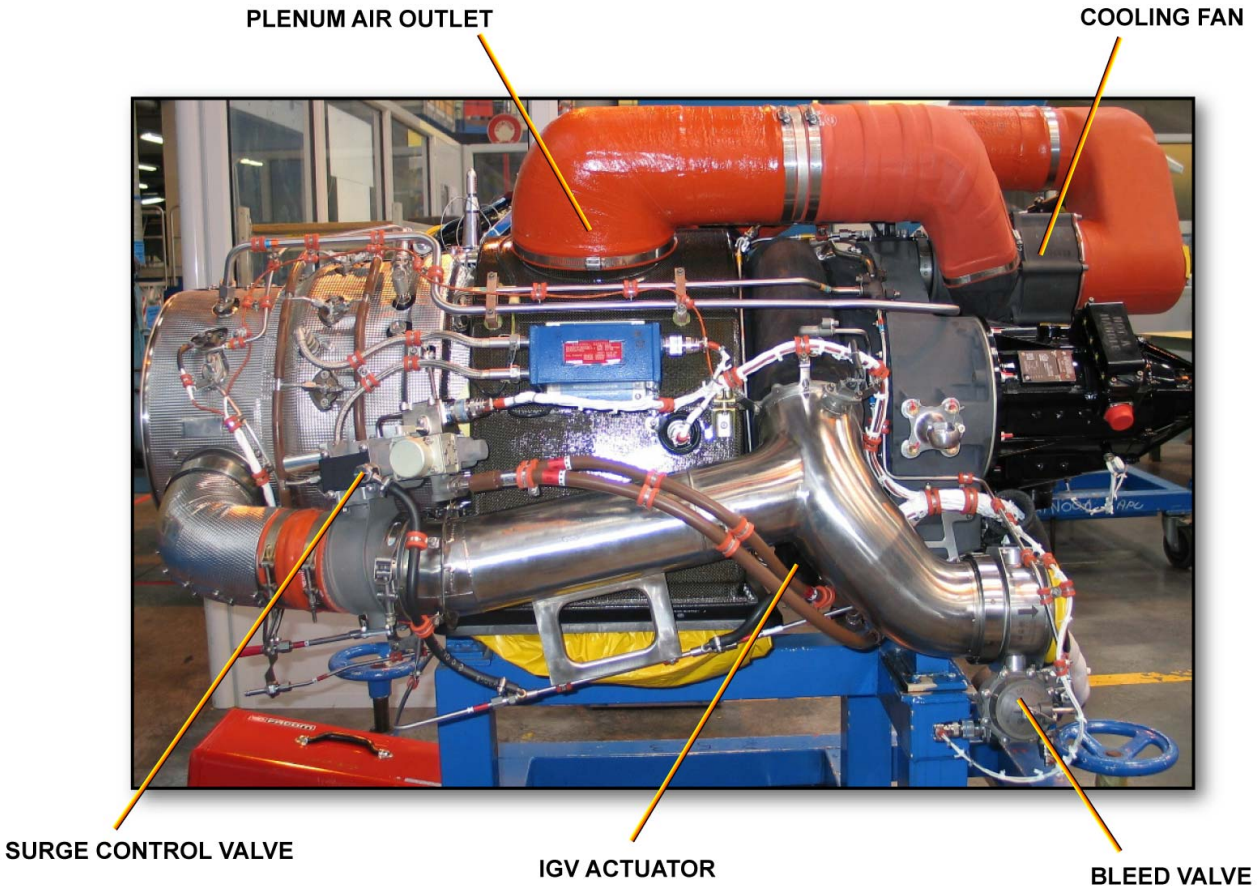
APU SYSTEM COMPONENT LOCATION (2)

AIR

The air/oil cooler, the compartment cooling valve, the permanent cooling outlet and the PT and P transducers are installed around the APU. Location of the plenum air outlet, the cooling fan, the bleed valve, the surge control valve and the IGV actuator.


AIR/OIL COOLER
COMPARTMENT COOLING VALVE
PERMANENT COOLING OUTLET
PT AND ΔP TRANSDUCER
VIDE

AIR


PLENUM AIR OUTLET
COOLING FAN
SURGE CONTROL VALVE
IGV ACTUATOR
BLEED VALVE

AIR

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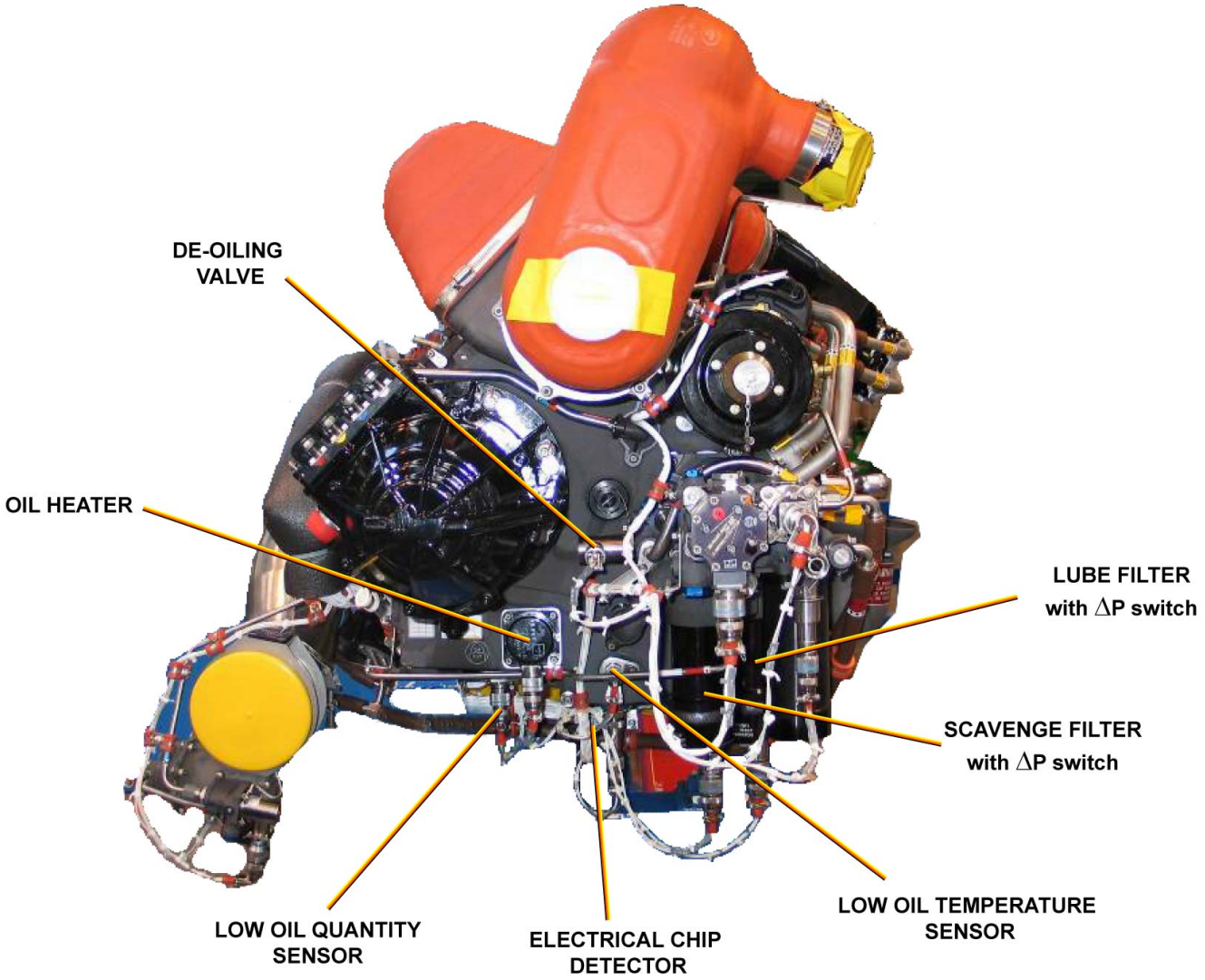
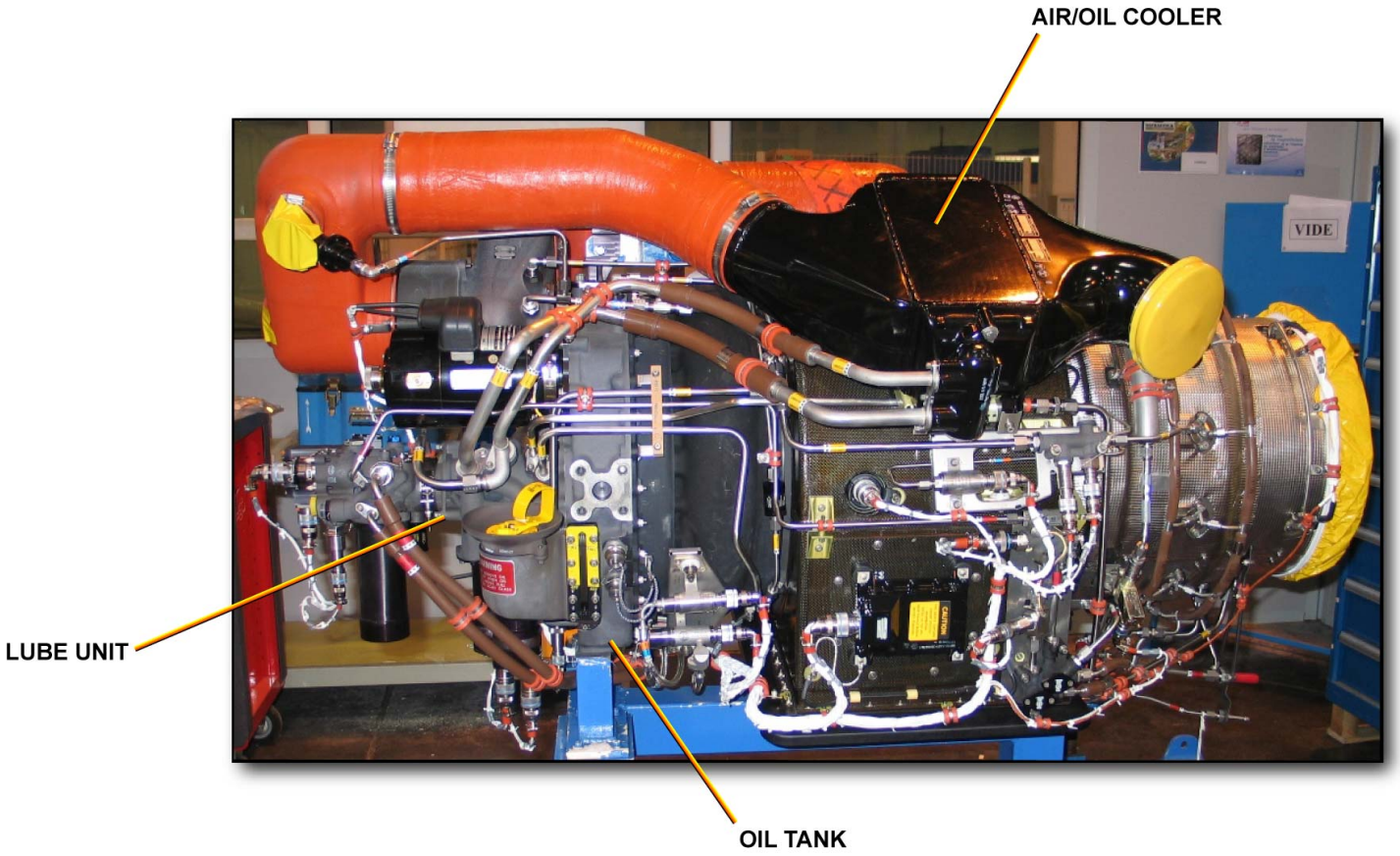
APU SYSTEM COMPONENT LOCATION (2)

OIL

Location of the de-oiling valve, the low oil quantity switch, the oil heater, the electrical chip detector, the low oil temperature sensor, the lube filter with P switch and the scavenge filter with P switch.
Location of the air/oil cooler, the lube unit and the oil tank.


DE-OILING VALVE
OIL HEATER
LUBE FILTER with ΔP switch
SCAVENGE FILTER with ΔP switch
LOW OIL TEMPERATURE SENSOR
LOW OIL QUANTITY SENSOR
ELECTRICAL CHIP DETECTOR

OIL



OIL

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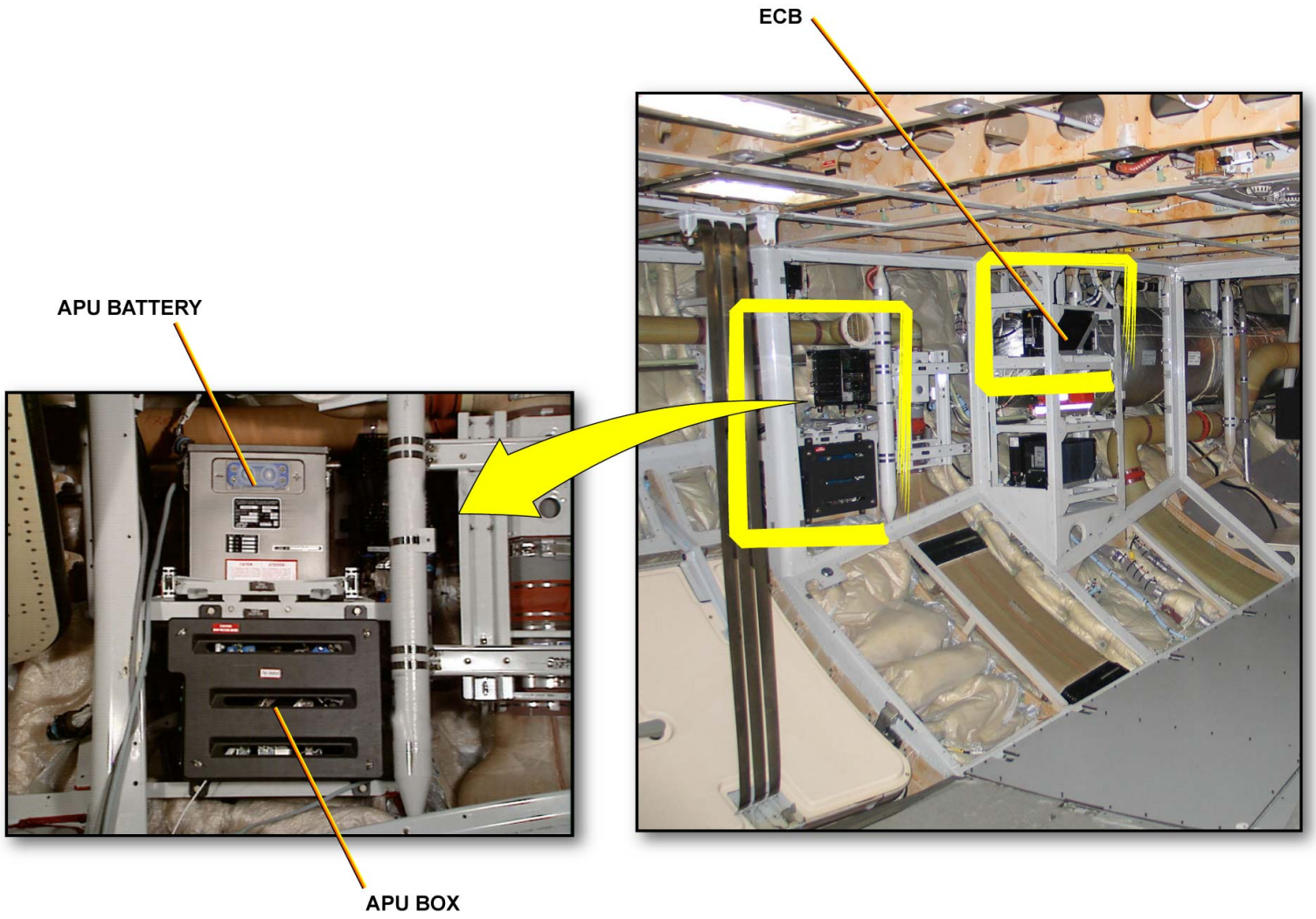
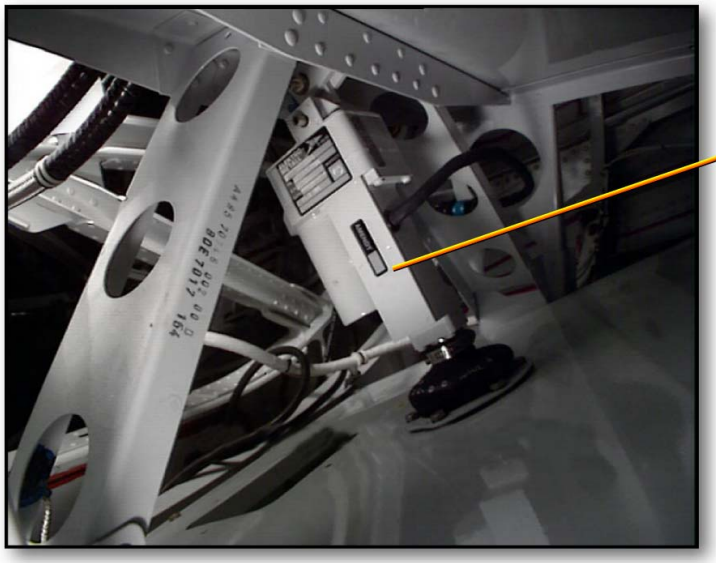
APU SYSTEM COMPONENT LOCATION (2)

IGNITION & STARTING

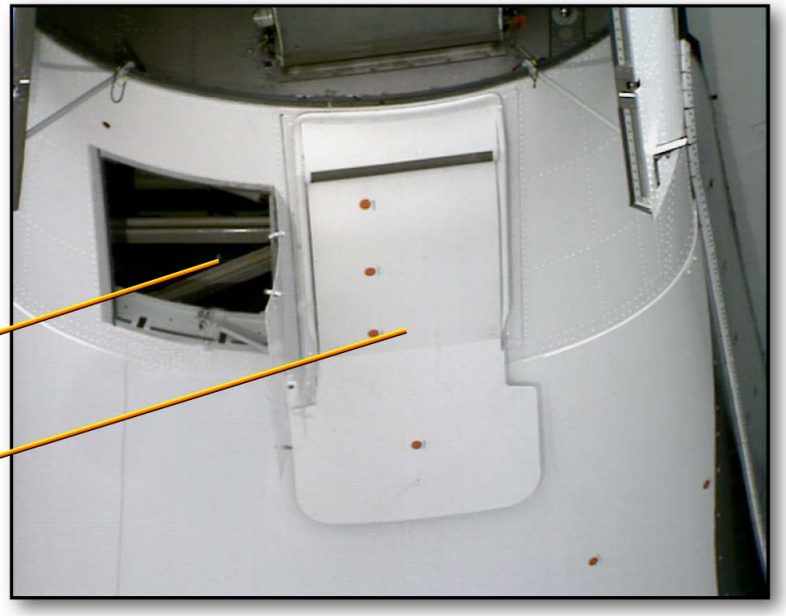
Location of the APU battery, the APU box and the ECB.
Location of the air intake flap actuator and the flap.
Location of the
A
PU starter, the DMM and the EGT thermocouples.
Location of the igniter plugs and the ignition unit.



IGNITION & STARTING



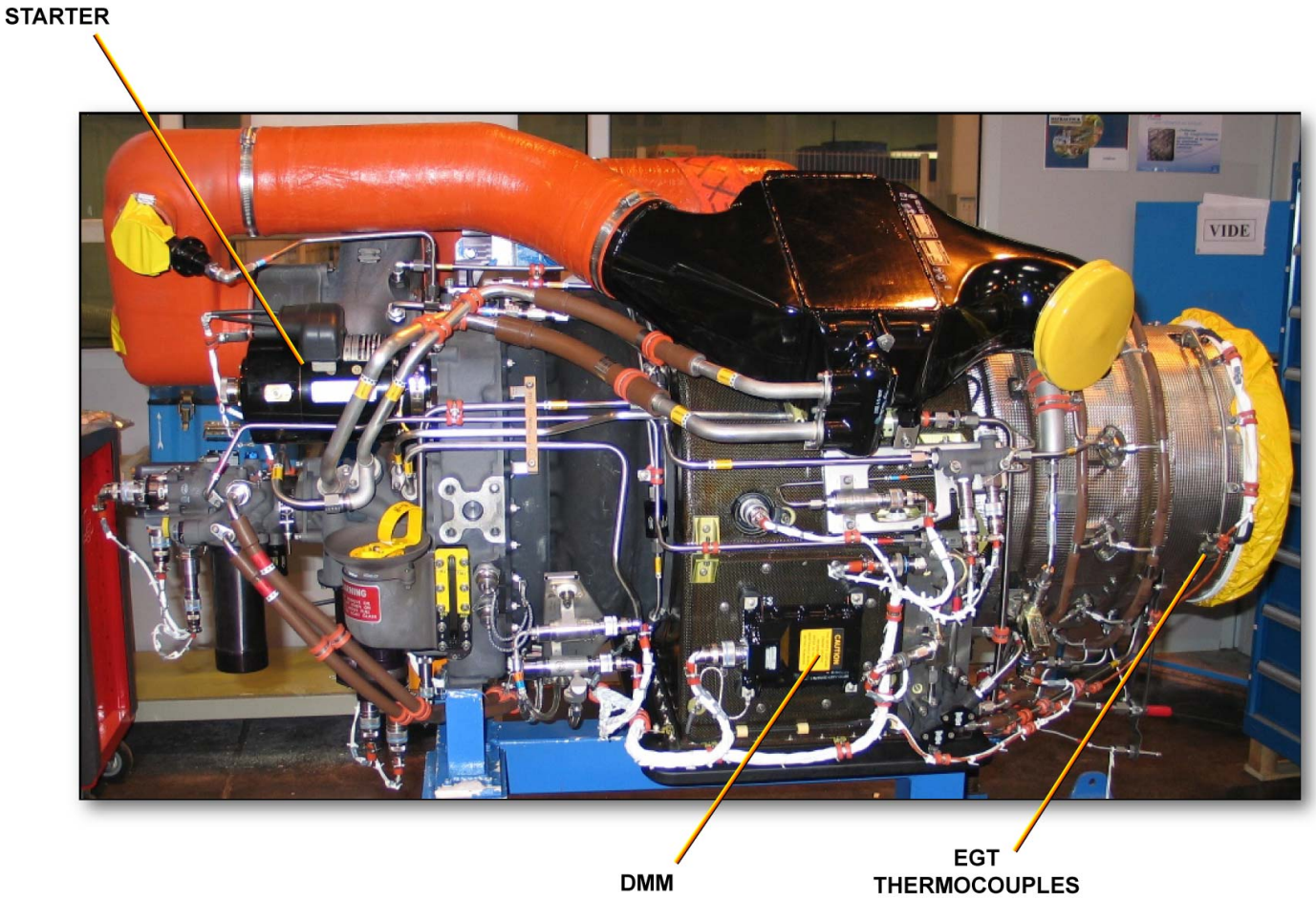
AIR INTAKE FLAP ACTUATOR



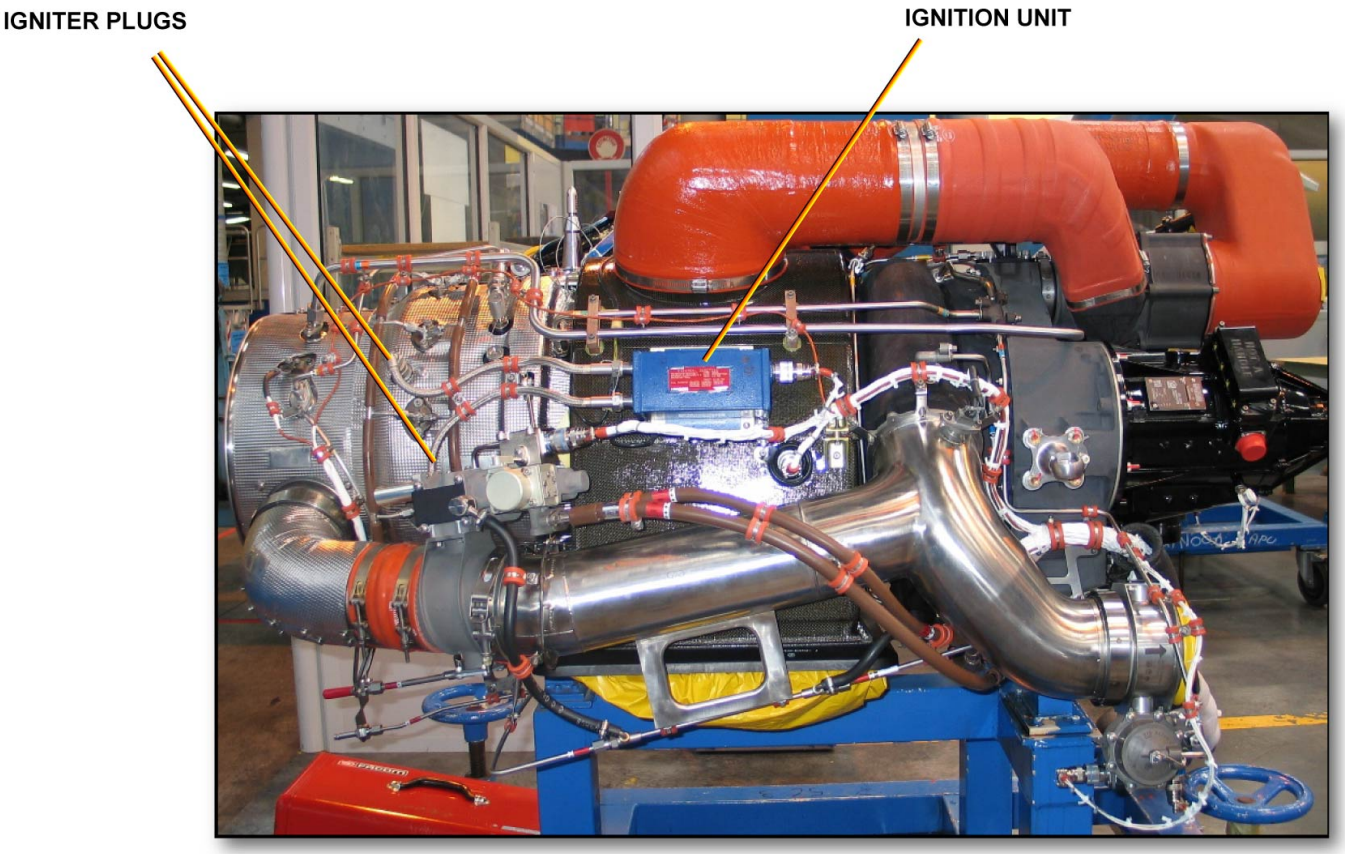
ACCESS TO FLAP ACTUATOR

FLAP

IGNITION & STARTING



IGNITION & STARTING



IGNITION & STARTING

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APU SYSTEM CONTROL & INDICATING (2)

LOCATE CONTROL/INDICATING IN COCKPIT

APU / ECB POWERING

ANIMATED SCHEMATIC

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GCL13151 - GEHT0M0 - FM49IZLEVEL0201

APU GENERAL D/O (3)

GENERAL

The Auxiliary Power Unit (APU) power plant GTCP331-350 is divided into different sub-systems, which are:
- the engine system including three basic modules, the power section, the load compressor, the accessory drive gearbox,
- the APU mounts system,
- the air intake system,
- the draining system,
- the exhaust system.

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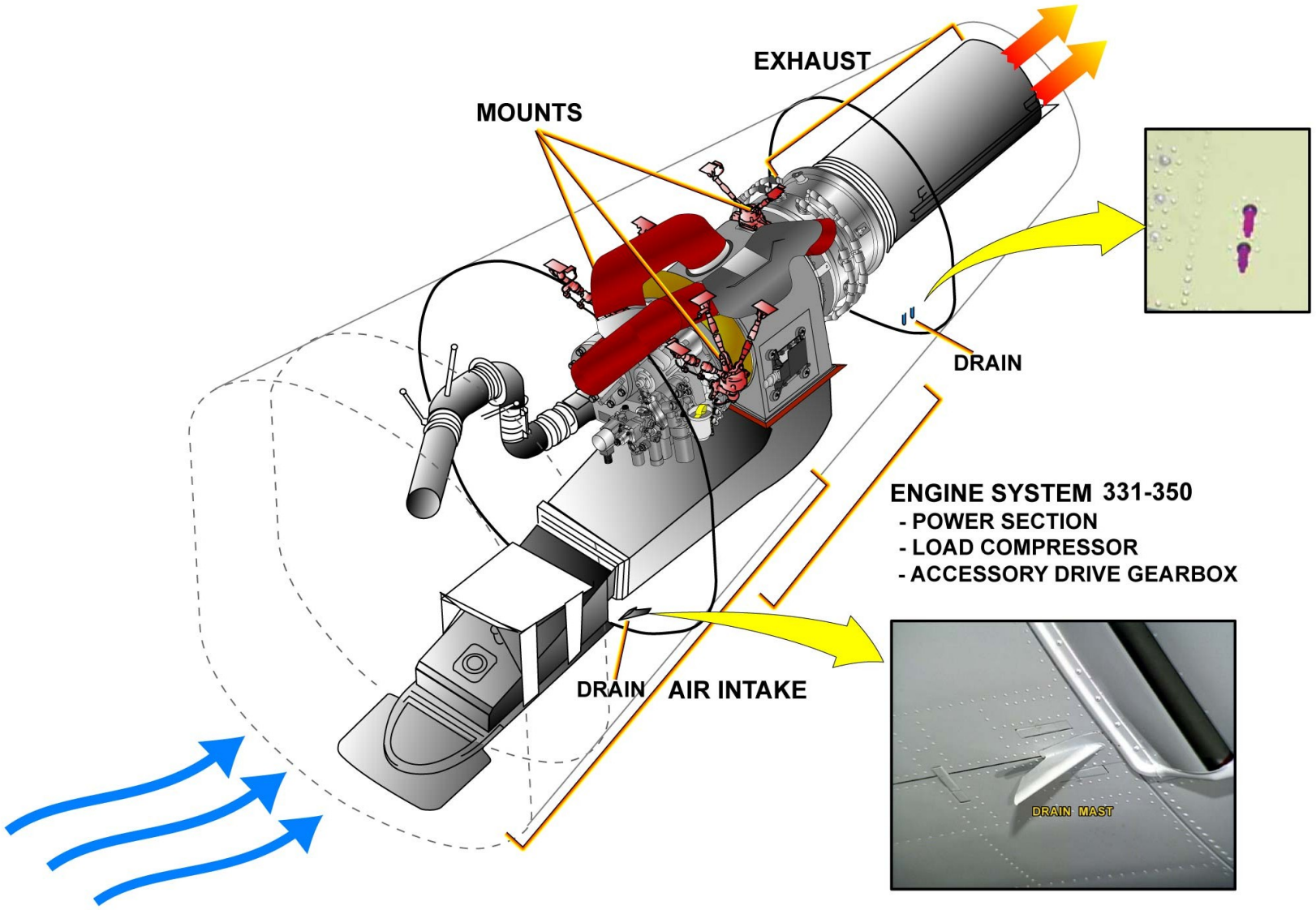
EXHAUST
MOUNTS
DRAIN
ENGINE SYSTEM 331-350
- POWER SECTION
- LOAD COMPRESSOR
- ACCESSORY DRIVE GEARBOX
DRAIN
AIR INTAKE
DRAIN MAST

GENERAL

APU GENERAL D/O (3)

ENGINE POWER SECTION

The power section of the GTCP331-350 system supplies the shaft power to drive:
- the load compressor,
- the accessory drive gearbox and the electrical generator. It is built up by the static structure and the rotating group. The static structure comprises the engine compressor case and the combustion chamber.
The rotating group, including the centrifugal compressor and turbine, is a single shaft assembly supported with a ball bearing located at the FWD end and a roller bearing located at the aft end. Both bearings are designed with a lubricated outer race to damp vibrations. Their 100% operation speed is 41730 rpm.

ENGINE COMPRESSOR

The engine compressor is a two-stage centrifugal compressor. Each compressor stage has an impeller and a diffuser. The role of the engine centrifugal compressor is to increase and to guide the air pressure through deswirl vanes into the combustion chamber.

COMBUSTION CHAMBER

The combustion chamber is of a reverse-flow annular design and surrounds the turbine hub containment. While the compressed air is in the combustion chamber, fuel is atomized and mixed into the air. During the combustion, the expanded gas stream is directed to the turbine where it changes its energy into rotational movement.

TURBINE

The turbine of the GTCP331-350 power section is of the three-stage axial design. The turbine rotors are the rear part of the main shaft. Their 100% operation speed is 41730 rpm.

LOAD COMPRESSOR

The load compressor module supplies compressed air to the A/C pneumatic system. It is installed between the power section and the accessory drive gearbox. The load compressor components are:
- the Inlet Guide Vanes (IGV) assembly,
- the load compressor impeller,
- the load compressor diffuser,
- the scroll.
A FWD roller bearing and an aft ball bearing support the rotating components of the load compressor. Both bearings are designed with a lubricated outer race to damp vibrations.

INLET GUIDE VANES ASSEMBLY

The variable IGV assembly supplies the correct amount of air to the APU load-compressor by modulating the vane position angles. It is composed of IGVs on a cylindrical rack mechanically connected to a fuel-operated actuator by an adjustable linkage rod.

LOAD COMPRESSOR IMPELLER

The load compressor impeller is a single stage impeller.

LOAD COMPRESSOR DIFFUSER

Downstream of the load compressor impeller is the radial diffuser. Multiple openings in the diffuser throat are used to collect the static pressure.

SCROLL

The scroll collects the bleed air at the diffuser outlet and supplies it to the bleed air duct.

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ACCESSORY DRIVE GEARBOX

The accessory drive gearbox is the FWD APU module. It is connected directly to the load compressor module, which transmits the shaft power from the power section.
The gearbox transmits the shaft power to the APU accessories and to the APU electrical generator, which are installed on the gearbox pads. It is also the oil reservoir for the APU oil system. The APU driven accessories are:
- the APU generator,
- the lubrication module and the Fuel Control Unit (FCU).

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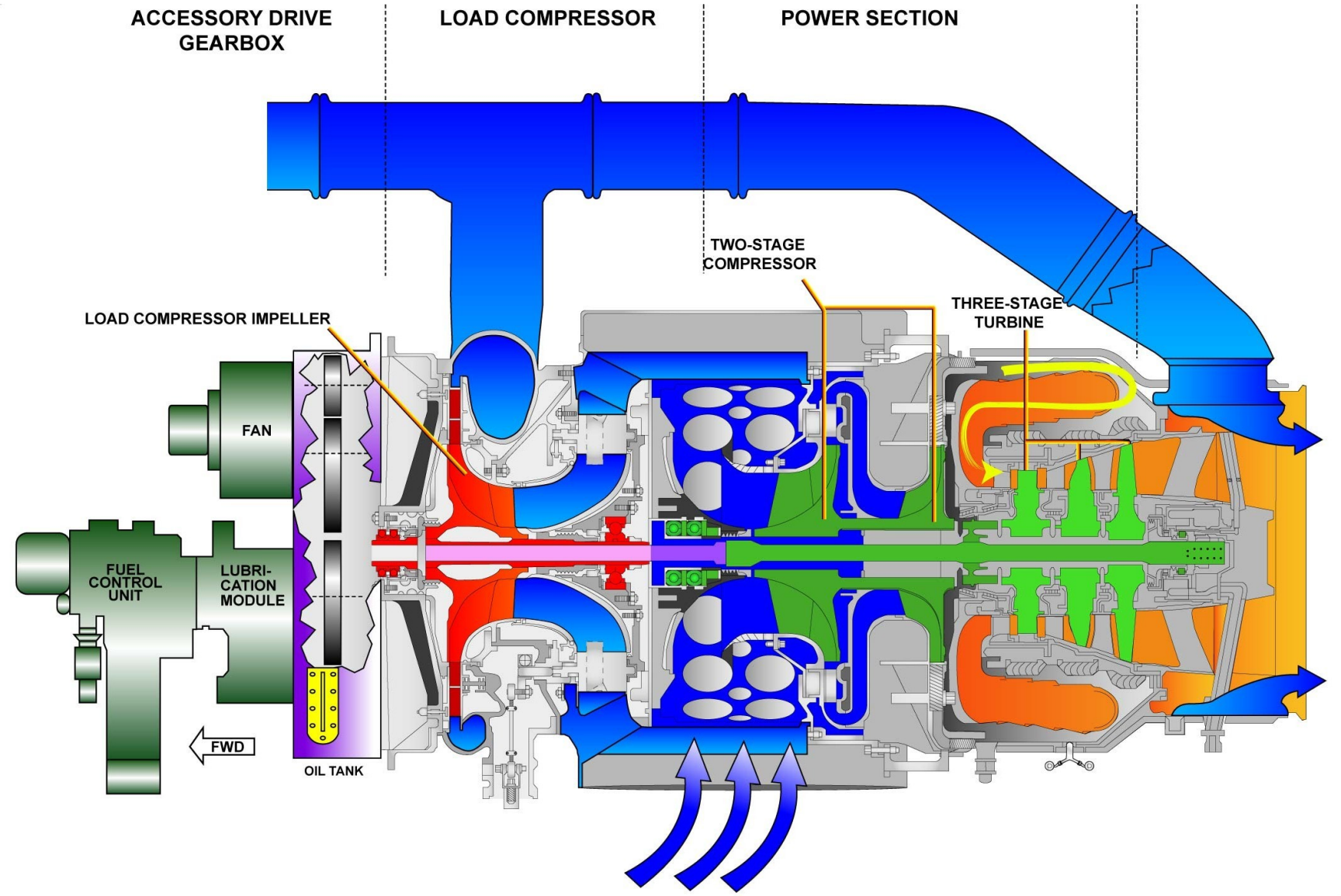

ENGINE POWER SECTION ... ACCESSORY DRIVE GEARBOX

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APU GENERAL D/O (3)

APU MOUNTS SYSTEM

The APU is installed on a three-point vibration-insulated mounting system. This system is composed of:
- seven structure brackets,
- seven rod assemblies,
- three APU mount brackets,
- three vibration isolators,
- two bonding straps.

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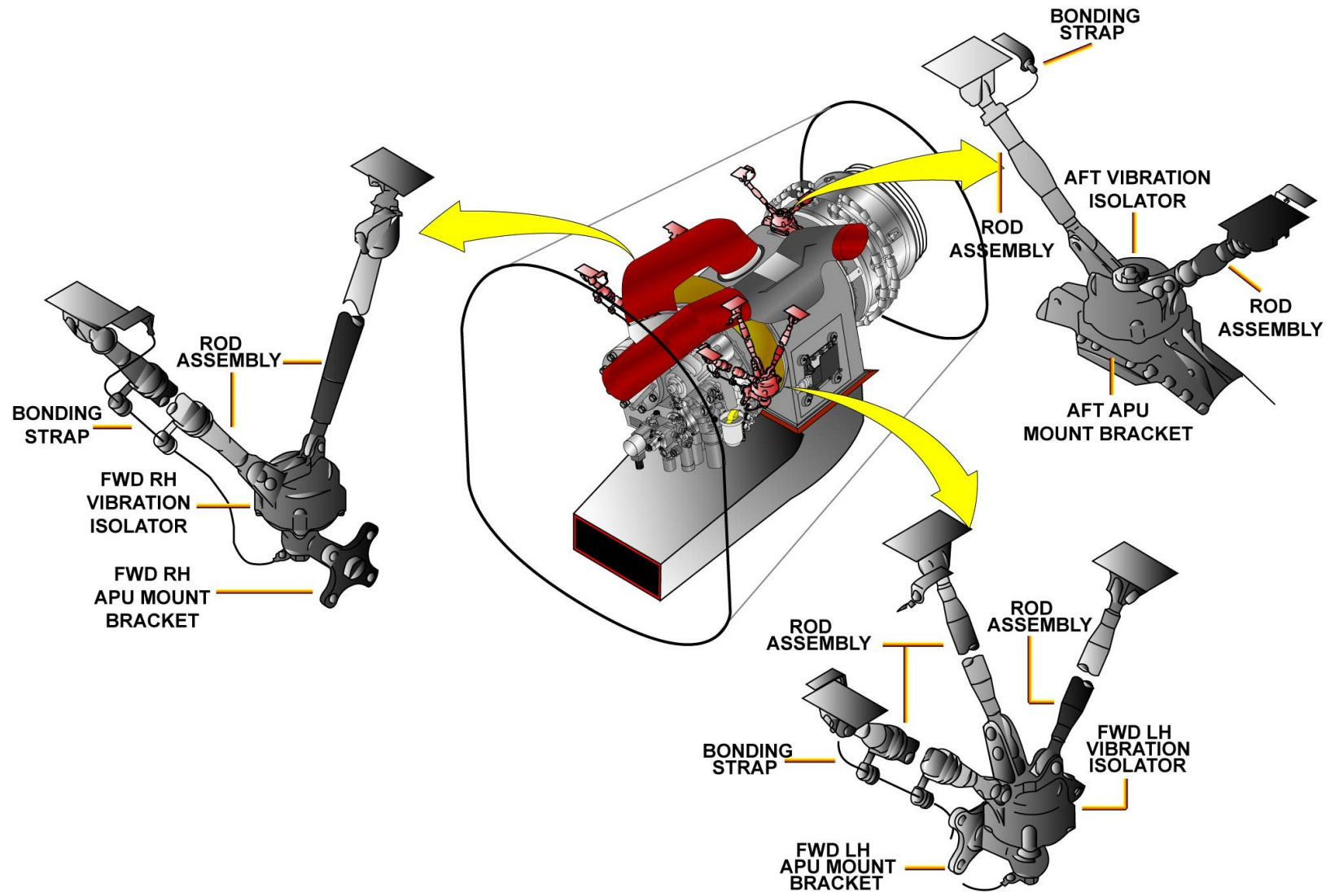

APU MOUNTS SYSTEM

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APU GENERAL D/O (3)

AIR INTAKE SYSTEM

The air intake system supplies ambient air to the plenum chamber of the APU. The main components of the air intake system are:
- the air intake diverter,
- the air intake assembly, with an air intake nose, an air intake flap and an air intake flap actuator,
- the air intake duct.

The Electronic Control Box (ECB) supplies the necessary electrical power for the operation of the air intake flap actuator. The two limit switches and the two position switches control the position of the air intake flap actuator. When the A/C is on the ground with no electrical power available or in case of flap actuator failure, the air intake flap can be operated manually by a manual override device.

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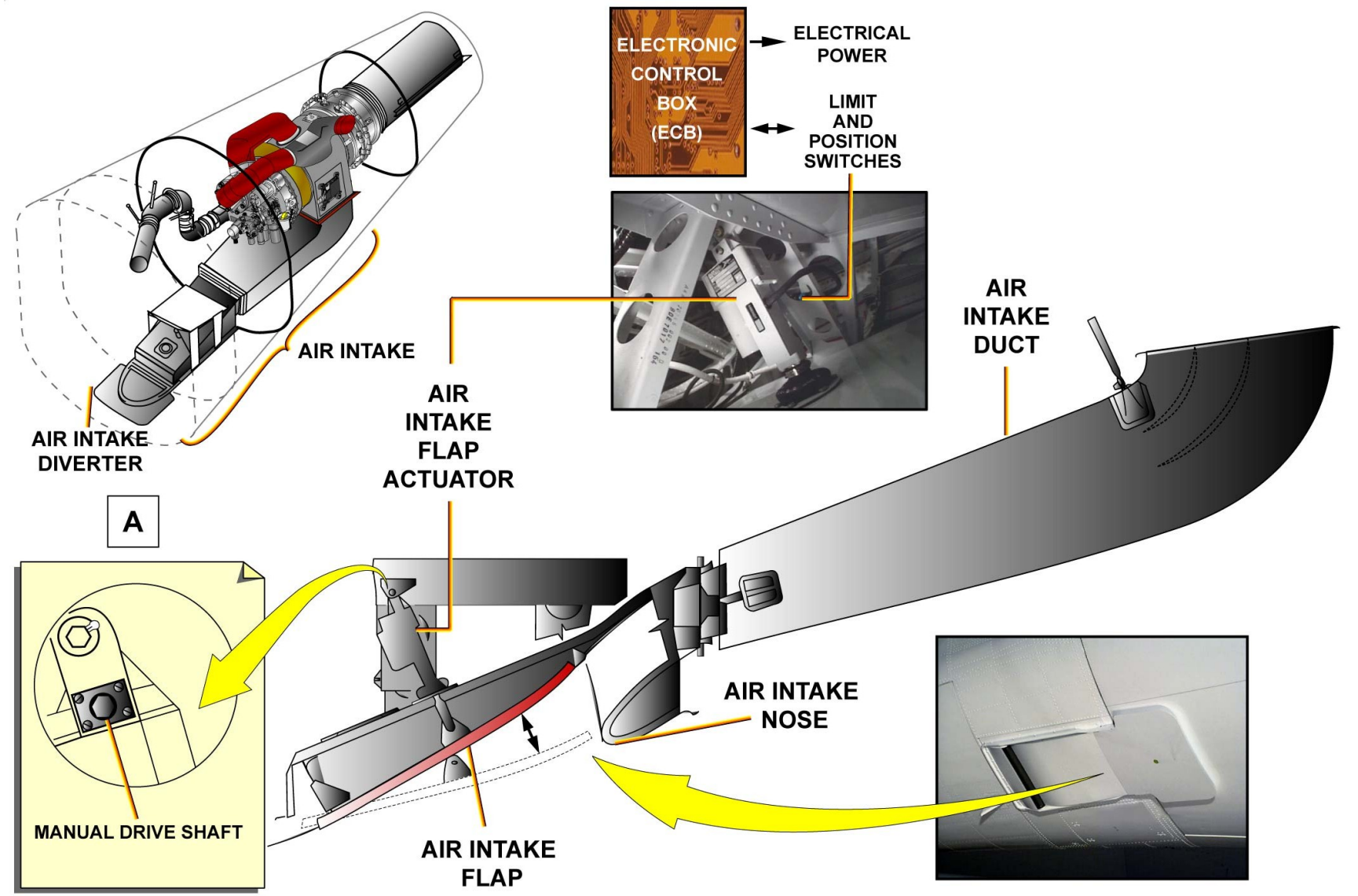

AIR INTAKE SYSTEM

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APU GENERAL D/O (3)

DRAIN SYSTEM

The power plant drain system is divided into two subsystems:
- the engine drain line system,
- the accessory drain line system.

The engine drain line system removes the subsequent excess fluids:
- the fuel, rainwater and/or condensed water from the exhaust muffler,
- the fuel, rainwater and/or condensed water from the APU exhaust cone,
- the fuel and condensed water from the combustion chamber and the combustion chamber drain valve.

The accessory drain line system removes subsequent excess fluids:
- fuel leakage and/or oil leakage from the FCU and the oil pump module, through the drain port check valve,
- fuel leakage from the surge control valve,
- fuel leakage from IGV actuator.

An APU plumbing connects the engine and accessory drain line systems to outboard drain tubes.

A FWD drain mast installed on the left APU compartment access door makes sure that the APU compartment fluid is drained overboard.

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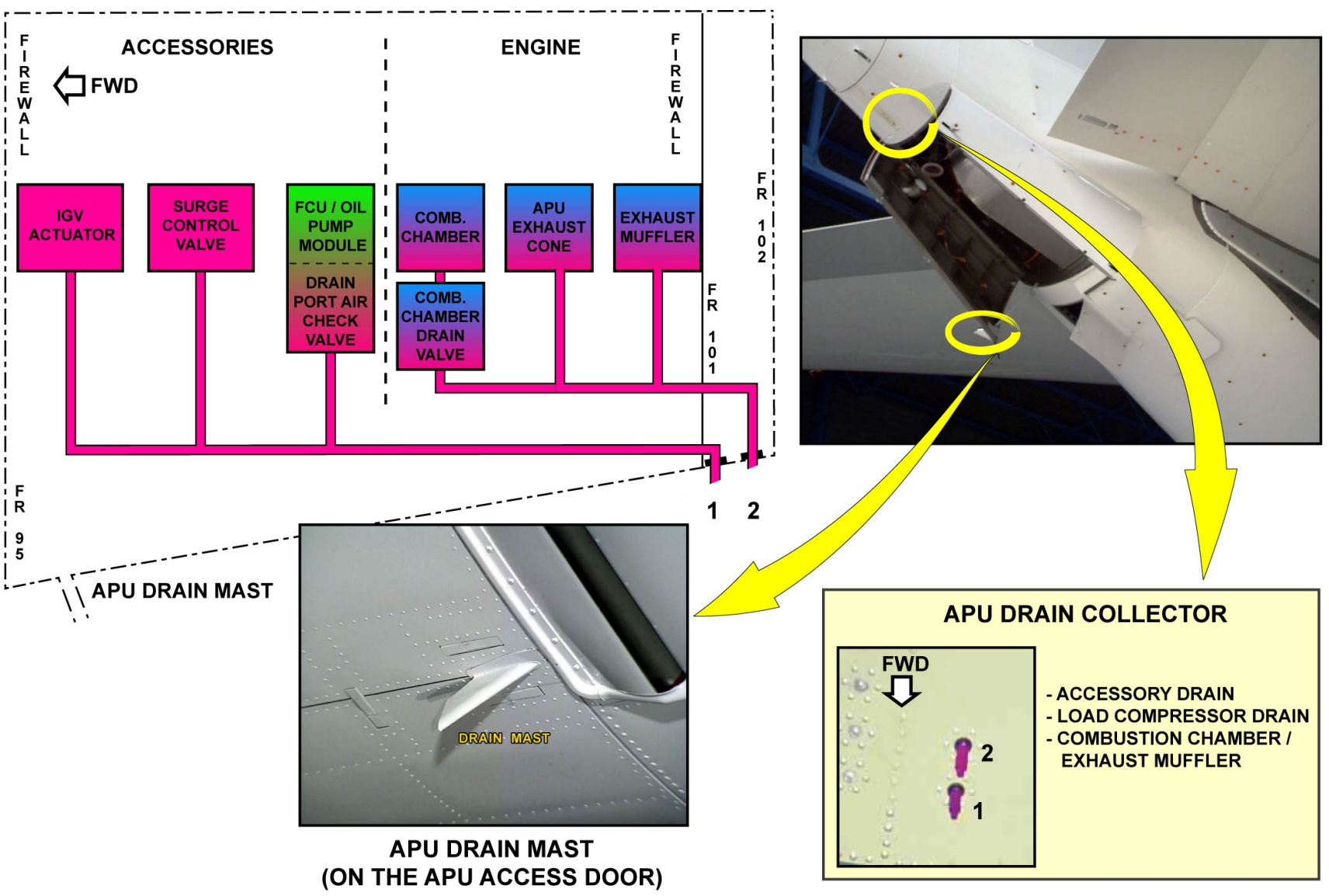

DRAIN SYSTEM

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APU GENERAL D/O (3)

EXHAUST

The APU exhaust system ducts the APU GTCP331-350 exhaust gases overboard; its secondary function is to decrease the exhaust noise level.
The exhaust system is made of two main components:
- the exhaust muffler assembly,
- the suspension.

The exhaust muffler assembly directs the exhaust gas flow to the ambient air, reducing the exhaust noise. It is composed of a flexible connection, which compensates expansion and contraction between the APU and the exhaust muffler caused by changes in temperature. The exhaust muffler suspension has two guide rails, which are part of the exhaust muffler compartment structure. They have a U shape. On the exhaust muffler there are four mount brackets. These fit into guide rails allowing thermal expansion. The exhaust muffler has a thermal insulation. It keeps the temperature at the external surface of the exhaust muffler to a limit of 200°C.

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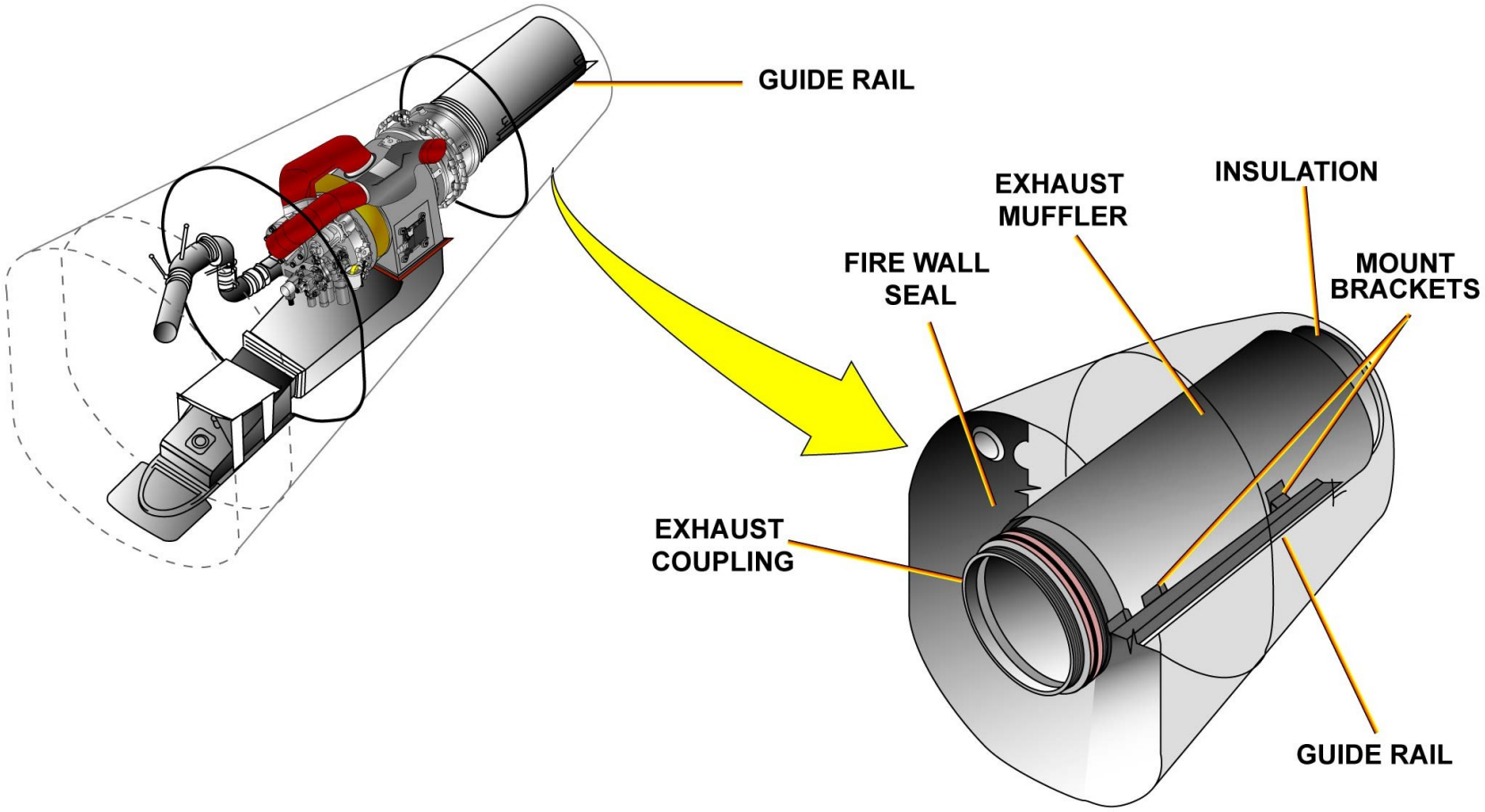
THE EXHAUST MUFFLER ASSEMBLY AND THE SUSPENSION



EXHAUST

APU FUEL D/O (3)

GENERAL

The Auxiliary Power Unit (APU) fuel system supplies metered fuel to sustain combustion. [It is also used for Inlet Guide Vane (IGV) and surge control valve actuators operation.
APU fuel system indications are displayed on the SD.

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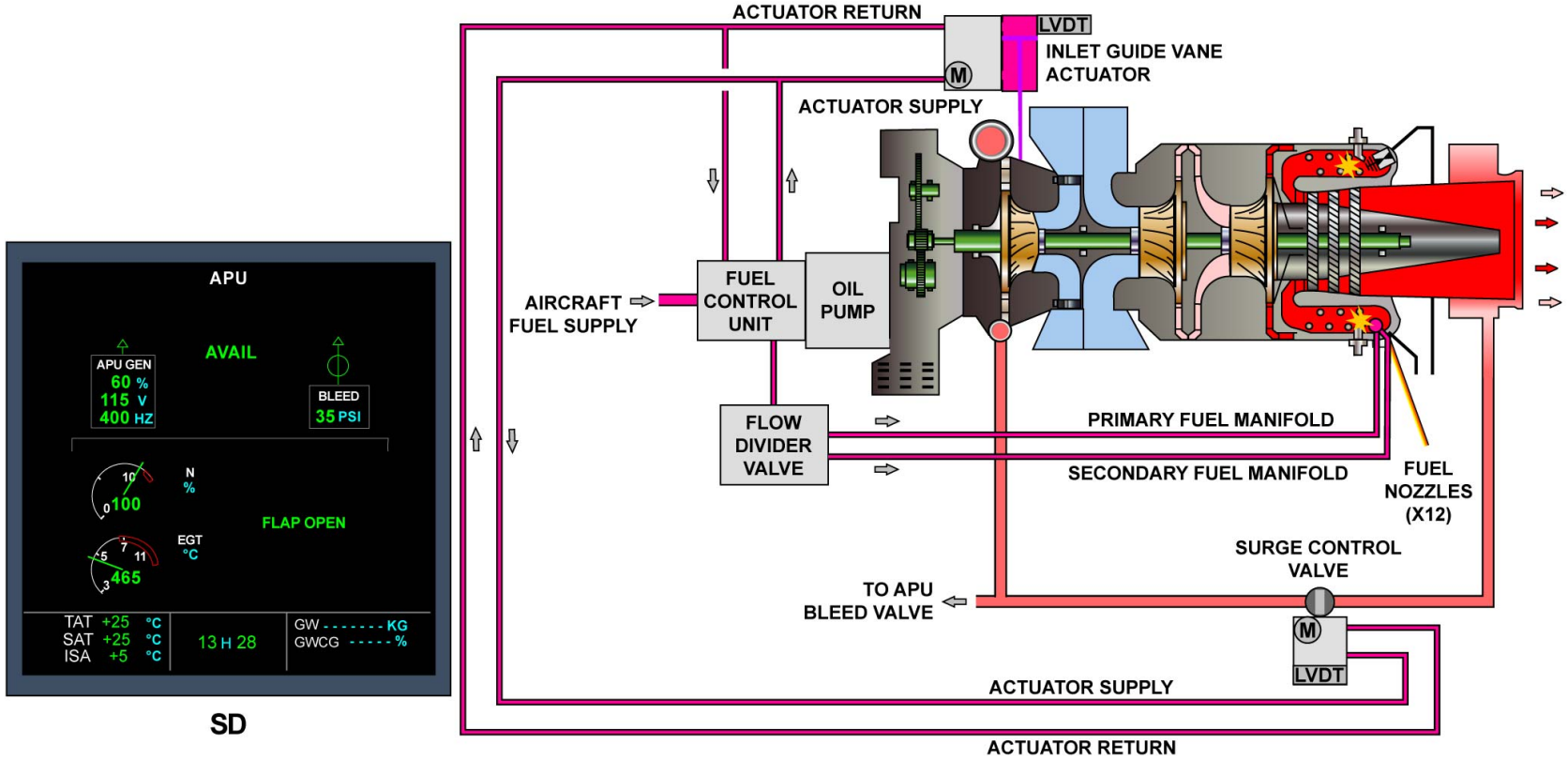
ACTUATOR RETURN
LVDT
INLET GUIDE VANE ACTUATOR
M
ACTUATOR SUPPLY
AIRCRAFT FUEL SUPPLY
FUEL CONTROL UNIT
OIL PUMP
FLOW DIVIDER VALVE
PRIMARY FUEL MANIFOLD
SECONDARY FUEL MANIFOLD
FUEL NOZZLES (X12)
SURGE CONTROL VALVE
TO APU BLEED VALVE
M
LVDT
ACTUATOR SUPPLY
ACTUATOR RETURN
APU
AVAIL
APU GEN
60 %
115 V
400 HZ
BLEED
35 PSI
N
%
100
FLAP OPEN
EGT
°C
465
TAT +25 °C
SAT +25 °C
ISA +5 °C
13 H 28
GW ------- KG
GWCG ----- %
SD

GENERAL

APU FUEL D/O (3)

FUEL CONTROL UNIT

The Fuel Control Unit (FCU) supplies the fuel quantity which is necessary for the APU operation. It also supplies the necessary fuel to operate the IGV and the SURGE CONTROL VALVE actuators.
The FCU is composed of:
- an inlet filter,
- a high pressure pump,
- a high pressure filter,
- a torque-motor metering valve,
- a shut-off valve.

FUEL SCHEDULE

The Fuel Metering Valve (FMV) is a torque-motor metering valve. It is controlled by the Electronic Control Box (ECB) which schedules the fuel flow for start sequence, on-speed operation and shut-down sequence.

MUSCLE PRESSURE

Fuel muscle pressure is used to operate the surge control valve actuator and the load compressor IGV actuator.

FUEL SHUT-OFF

The ECB controls the fuel solenoid valve for positive fuel shut-off. The valve is controlled open during the start sequence, and closed during the stop sequence.

FLOW DIVIDER

The flow divider divides fuel into primary and secondary flows. During the start sequence, only the primary flow is supplied.
At the APU shutdown, compressor discharge stage 2 air blows out the residual fuel from the two manifolds during APU shutdown through an ecologic drain solenoid valve controlled by the ECB.

FUEL DISTRIBUTION

Fuel flows to the combustion chamber through 12 fuel nozzles. At the start sequence, only the primary flow is supplied, but at a preset fuel pressure, the secondary flow is supplied.

CONTROL AND MONITORING

The ECB controls the fuel system using the APU speed, EGT, and A/C demand signals during on-speed operation. It uses the APU speed, Exhaust Gas Temperature (EGT), fuel temperature and fuel flow during starting.
The APU boost pumps are monitored by the ECB through a pressure switch installed at the FCU inlet.
A visual filter-clogging indicator is used to monitor the fuel system contamination.

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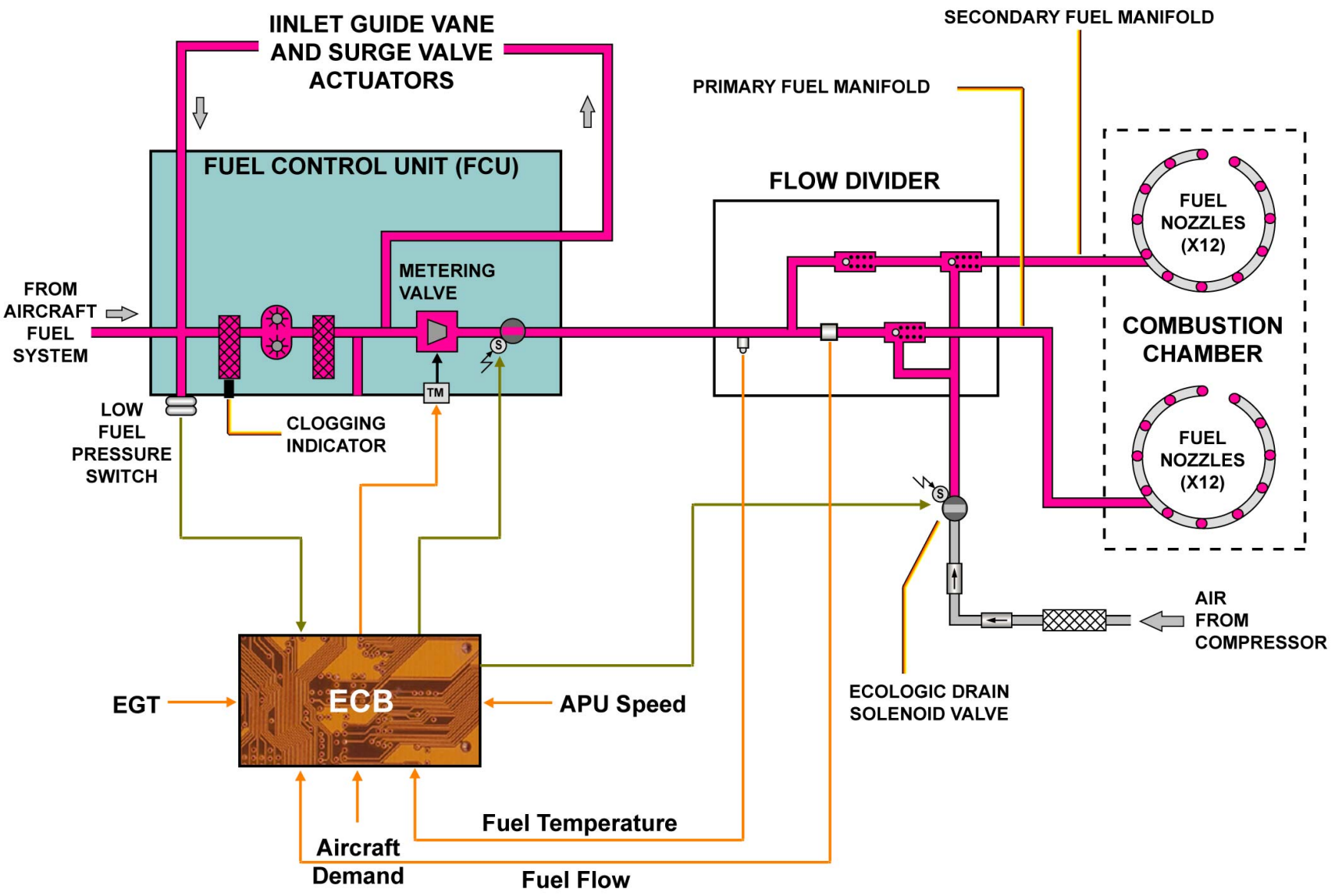

FUEL CONTROL UNIT ... CONTROL AND MONITORING

APU AIR D/O (3)

GENERAL

The air system delivers compressed air from the Auxiliary Power Unit (APU) load compressor and cools the accessory. The two subsystems are:
- bleed and surge air,
- accessory cooling.

BLEED AND SURGE SUBSYSTEM DESCRIPTION

The APU load compressor supplies bleed air to the pneumatic system. [Bleed air quantity is controlled by the load compressor Inlet Guide Vanes (IGVs) which are moved by a fuel-powered actuator. [A bleed air shut-off valve, pneumatically operated, lets or stops the bleed air flow to the pneumatic system.
A surge control valve prevents a load compressor surge, by discharging the excess of air in the exhaust. It is a butterfly-type valve hydraulically operated by fuel coming from the Fuel Control Unit (FCU). The valve has a Linear Variable Differential Transducer (LVDT) for position feedback.

BLEED AND SURGE AIR OPERATION

APU bleed air is delivered when all the following conditions are met:
- APU is running above 95% speed,
- APU bleed switch is selected,
- No bleed leak detected by the Bleed Monitoring Computers (BMCs),
- APU inlet pressure (P2) altitude is below 25,000 feet.

By pressing the APU BLEED P/B, if no leak is detected, the BMCs send a signal to the Electronic Control Box (ECB) which energizes the APU bleed valve solenoid. Using upstream bleed air pressure, the APU bleed valve fully opens.
Then, the ECB adjusts the IGVs actuator torque motor current according to the following parameters:
- the A/C bleed demand sent by the Zone Controller (ZC),
- the Load Compressor Inlet Temperature (LCIT),
- the Load Compressor Outlet Temperature (LCOT),
- P2.

The IGVs actuator moves under fuel pressure to the requested position which is fed back to the ECB using the actuator LVDT. Consequently the IGVs are set to a position satisfying the airflow demand.
To prevent an APU load compressor surge in the event of a higher flow delivered than actually used by the A/C systems, the ECB controls the torque motor of the surge control valve. The surge control valve torque motor current is calculated by the ECB from the comparison of the actual flow delivered and the selected flow from the IGVs setting.
A total pressure (PT) transducer, and a differential pressure transducer (P) send data to the ECB. [The actual flow is given by the ratio P/PT.
When the actual flow is greater than the selected flow, indicating a surge, the ECB adjusts the surge control valve torque motor current. The surge control valve actuator moves under fuel pressure and the valve opens, releasing the excess of air to the exhaust.
Feedback of the surge control valve is given to the ECB by an LVDT.
Once the surge condition disappears, the surge control valve goes back to the closed position.

ACCESSORY COOLING

A gearbox-driven fan draws air from the inlet plenum and forces it to pass through the oil cooler and from there overboard.
The fan also supplies air to the APU compartment through a pneumatic cooling valve which is fully closed in altitude. [An uncontrolled cooling orifice is used permanently for the cooling when the APU is running.

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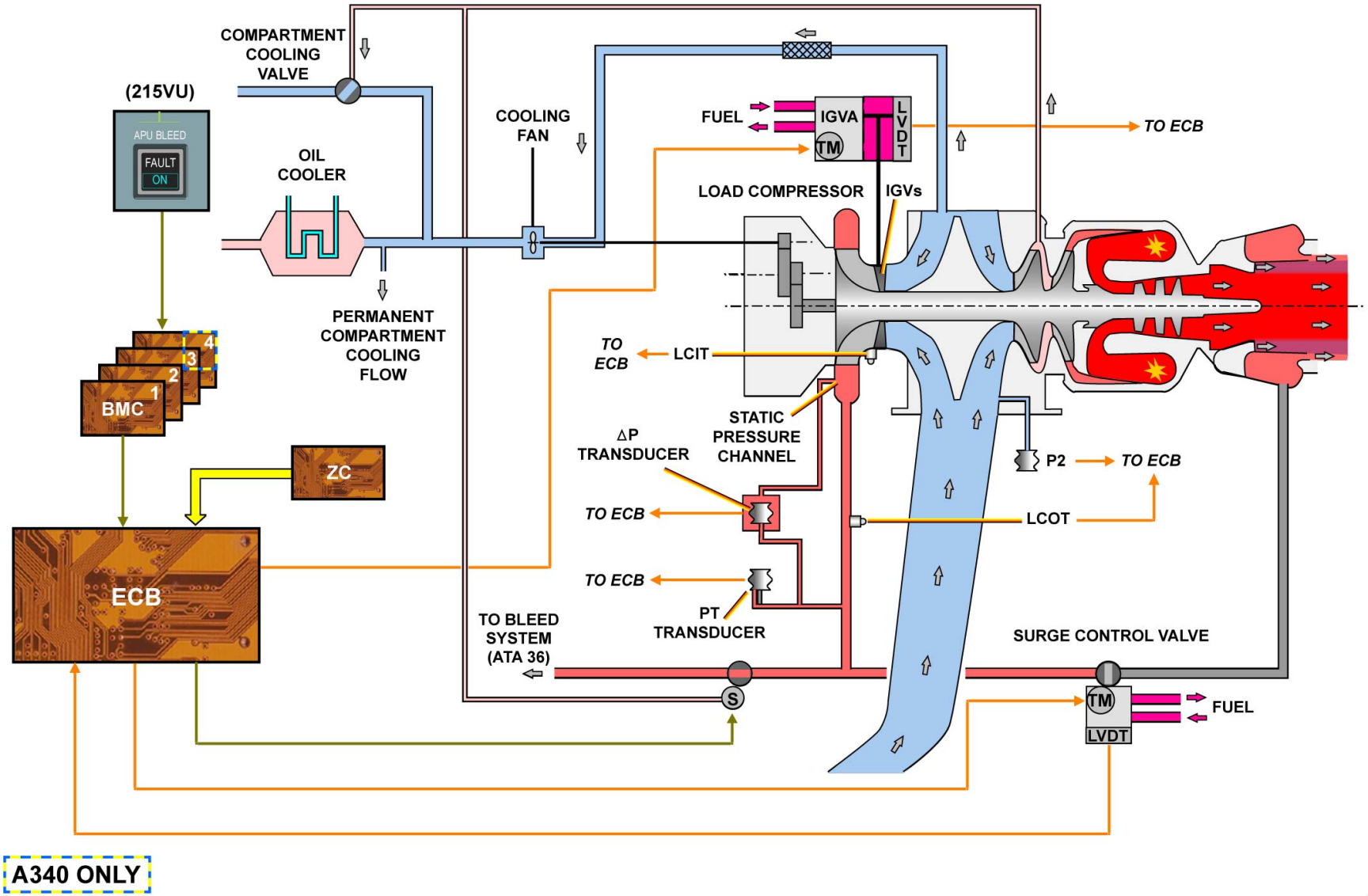

GENERAL ... ACCESSORY COOLING

APU OIL D/O (3)

LUBE MODULE DESCRIPTION

The lubrication module, also called lube module, is attached to the front of the gearbox. It provides continuous pressurized oil supply to APU components, and scavenges oil from lubricated components.
The lubrication module is a self-contained unit providing oil to:
- the generator,
- the gearbox,
- the main shaft bearings sump.

The lube module contains:
- a lube pump system and a scavenge pump system,
- a lube filter fitted with a differential pressure switch for clogging detection and a clogging visual indicator,
- a lube filter bypass valve,
- a generator scavenge filter also fitted with a differential pressure switch for clogging detection and a clogging visual indicator,
- a generator scavenge filter by-pass valve,
- an electrical chip detector,
- a solenoid de-oiling valve.

LUBE PUMP SYSTEM AND SCAVENGE PUMP SYSTEM

The lubrication section incorporates two gyrotor element scavenge pumps for clearing oil from the generator, and two single element gyrotor scavenge pumps for clearing oil from the APU mid-frame and turbine bearing cavity.

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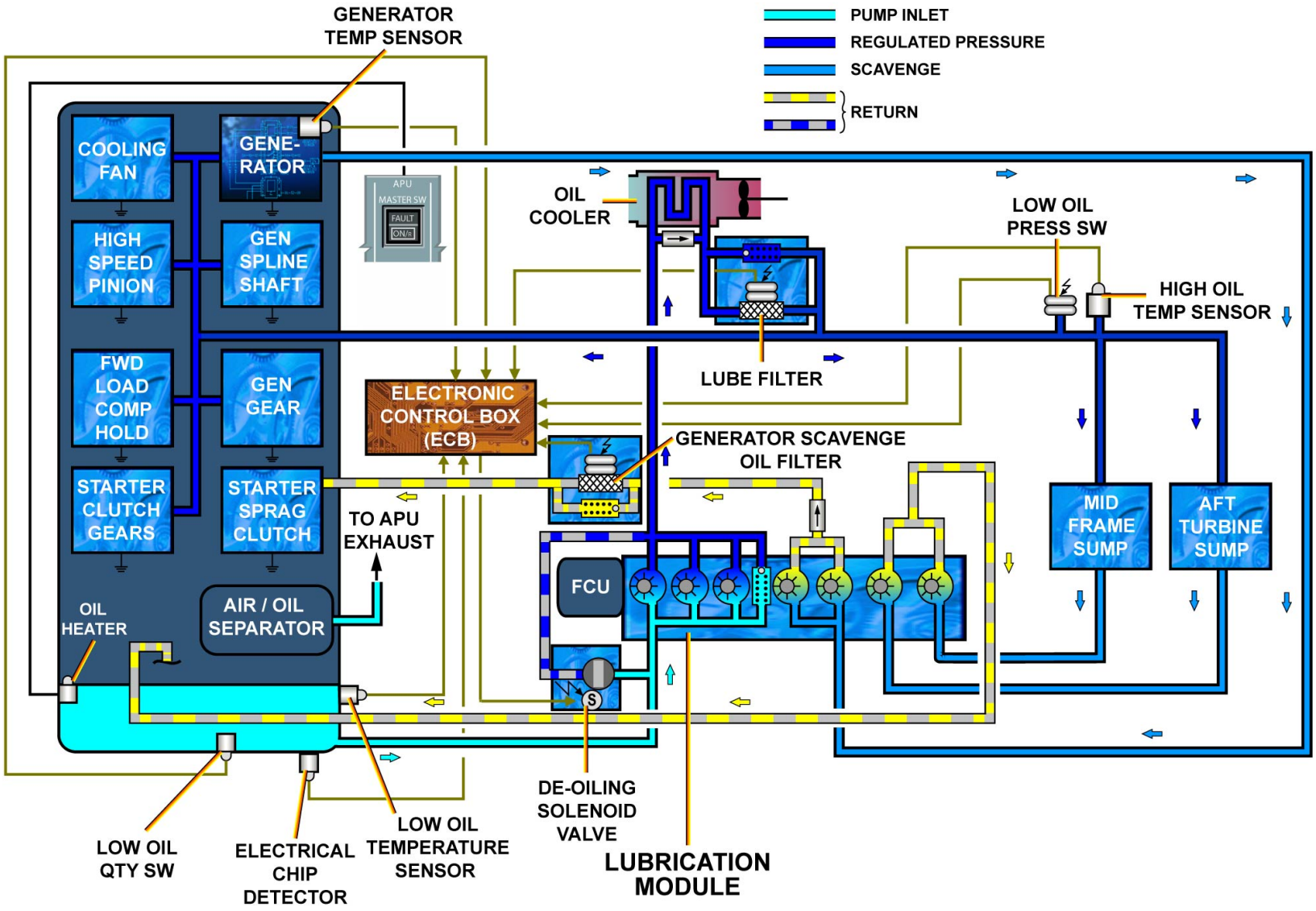

LUBE MODULE DESCRIPTION - LUBE PUMP SYSTEM AND SCAVENGE PUMP SYSTEM

GCL13151 - GEHT0M0 - FM49D200000003

APU OIL D/O (3)

LUBE MODULE DESCRIPTION (continued)

LOW OIL PRESSURE (LOP) SWITCH AND HIGH OIL TEMPERATURE (HOT) SENSOR

A Low Oil Pressure (LOP) switch monitors the regulated oil pressure. When the LOP finds that the oil pressure is too low, it transmits a discrete signal to the ECB. A High Oil Temperature (HOT) sensor measures the temperature of the oil downstream of the oil cooler. The ECB receives the temperature signal and thus monitors the APU oil temperature.

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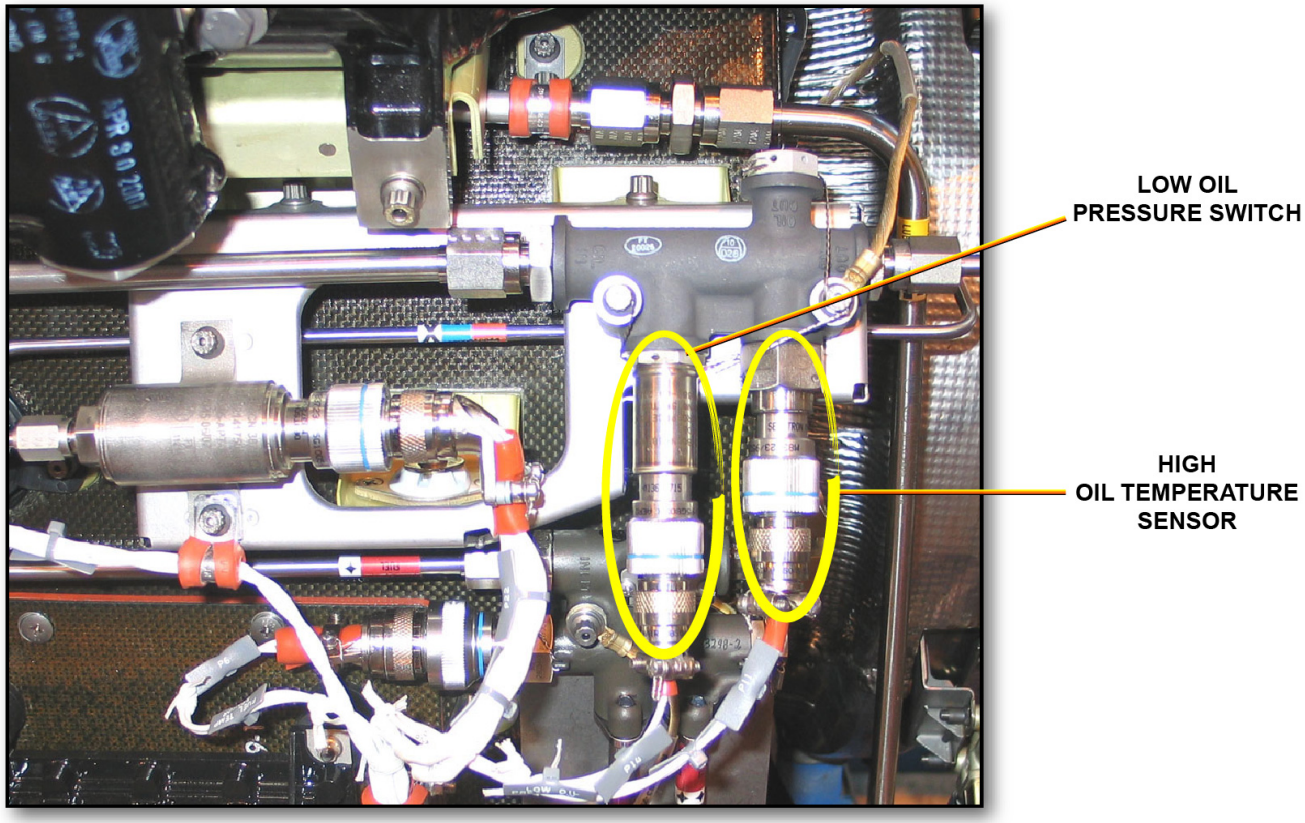

LUBE MODULE DESCRIPTION - LOW OIL PRESSURE (LOP) SWITCH AND HIGH OIL TEMPERATURE (HOT) SENSOR

GCL13151 - GEHT0M0 - FM49D2000000003

APU OIL D/O (3)

LUBE MODULE DESCRIPTION (continued)

LUBE AND SCAVENGE OIL FILTERS

The filters are contained in housings, which are threaded into the lubrication module housing. The same kind of filter is used in the lubrication and in the scavenge circuits. Both are replaceable and non-cleanable. Each filter housing is equipped with a visual clogging indicator and a differential pressure switch.

The differential pressure switches are LRUs that provide a remote, real-time indication to the ECB of impending bypass of corresponding filter. The actuation of either or both switches will cause an APU auto-shutdown, inhibited during flight.

Filter bypass valves are installed in the supply circuit and generator scavenge circuit of the lube module. These bypass valves allow continued APU operation with highly contaminated or blocked filter, when operating the APU in the auto-shutdown inhibition phase.

The visual indicator is designed to trigger at 25 +/-5 psid, the differential pressure switches at 35 +/-5 psid and the bypass valve to open at 65 +/-5 psid. Thus, the visual indication will be provided prior to the earliest possible switch actuation, and switch actuation prior to the opening of the bypass valve.

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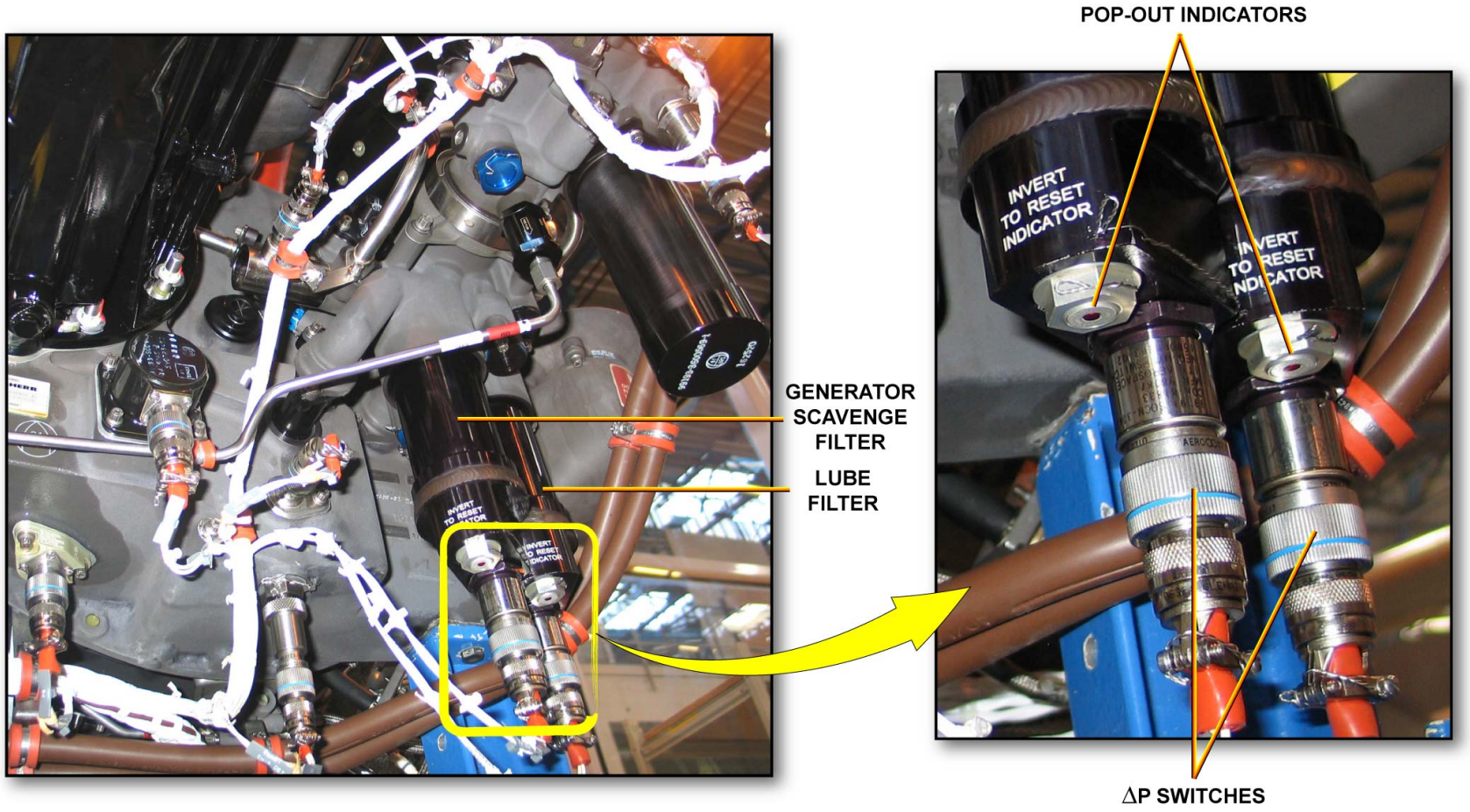

LUBE MODULE DESCRIPTION - LUBE AND SCAVENGE OIL FILTERS

APU OIL D/O (3)

LUBE MODULE DESCRIPTION (continued)

SOLENOID DE-OILING VALVE

The bypass de-oil solenoid valve is an LRU located on the bottom left hand side of the lube module. It opens to allow air to enter into the inlet side of the pressure pump under specific start conditions (depending on oil temperature, fuel temperature and aircraft altitude) and also during APU shutdown.

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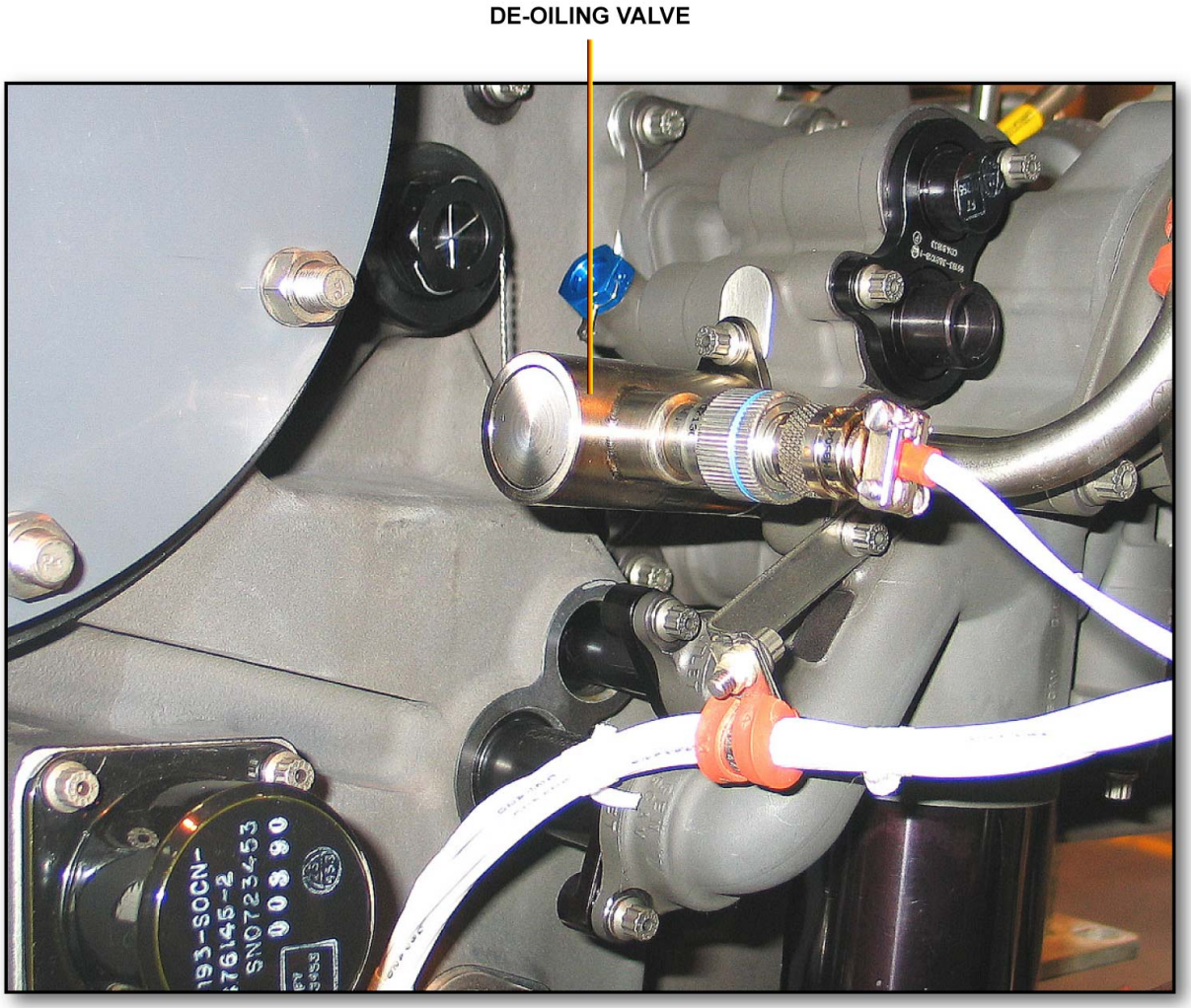

LUBE MODULE DESCRIPTION - SOLENOID DE-OILING VALVE

APU OIL D/O (3)

GEARBOX DESCRIPTION

The lower part of the gearbox is used as oil reservoir. The total capacity of the oil reservoir is 8.5 liters. The gearbox is fitted with:
- a gravity fill port and a pressure fill port,
- an oil level sight glass,
- a low oil quantity switch,
- a low oil temperature sensor,
- an oil heater,
- an electrical chip detector,
- an air/oil separator.

Within the gearbox, the cooling fan pad and the starter motor pad are internally supplied with oil.

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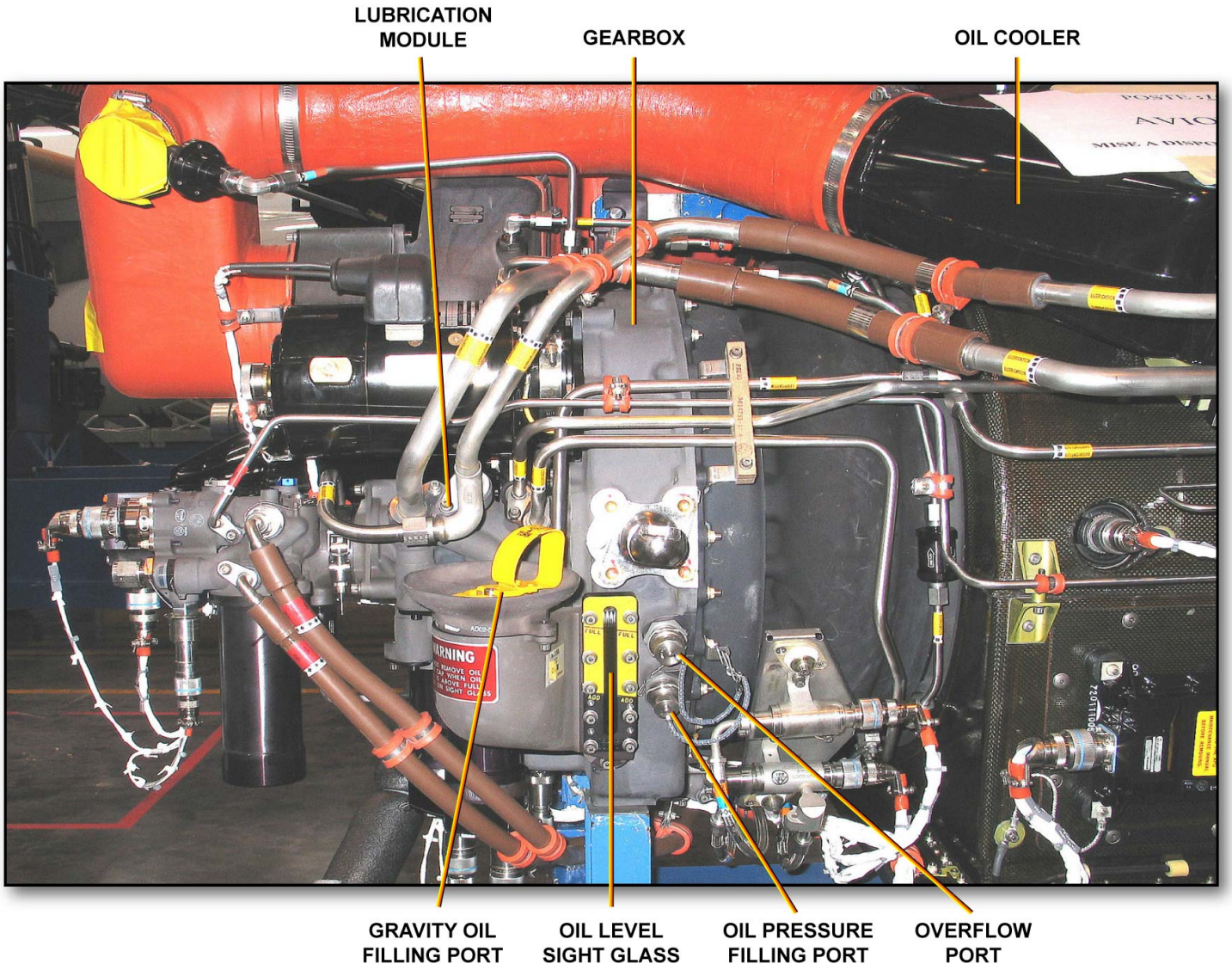

GEARBOX DESCRIPTION

APU OIL D/O (3)

GEARBOX DESCRIPTION (continued)

GRAVITY FILLING PORT, PRESSURE FILLING PORT AND OIL OVERFLOW PORT

The gravity filling port is on the left-hand side lower part of the gearbox. It gives a method for the servicing of the Auxiliary Power Unit (APU) with oil and it is big enough to have a servicing from a 1-quart can. It has a positive locking device when closed. A pressure filling port and an oil overflow port are also installed for remote fill servicing.

OIL LEVEL SIGHT GLASS

A sight glass is installed on the gravity fill port for oil level indication. It has a marking for the levels when the APU is not running.
There is a FULL mark and a ADD mark. The "ADD" mark is equal to an oil quantity of 4.1 liters (low oil level); the "FULL" mark is equal to a level of 7.3 liters.

LOW OIL QUANTITY SWITCH

The low oil quantity switch is located next to the gravity fill oil cap on the gearbox. It uses dual reed switches for two separate oil level indications, which are activated by a magnet/float combination when the oil level changes.

LOW OIL TEMPERATURE SENSOR

The low oil temperature sensor is installed on the gearbox housing. It measures the temperature of the oil in the reservoir. The sensor transmits the temperature signal to the Electronic Control Box (ECB).

OIL HEATER

The oil heater is a Line Replaceable Unit (LRU) located on the lower left side of the gearbox. The APU oil heater has an oil temperature switch and a nickel-iron alloy coil. It uses an independent aircraft 115 VAC power source to increase the oil temperature. The oil temperature switch is a "thermal temperature-delay switch" which measures the temperature of the oil in the gearbox sump.
As soon as the aircraft is powered, if the APU master switch is OFF and the oil temperature is less than 21°C, the oil heater is automatically switched ON. It is deactivated when the oil temperature reaches 43°C. Note that the oil heater has no direct connection to the ECB.

ELECTRICAL CHIP DETECTOR

The gearbox electrical chip detector LRU is installed in the drain plug. The chip detector detects the magnetic particles from the lowest point in the oil sump.
The gearbox electrical chip detector contains an electrical contact gap. This gap closes when a sufficient quantity of metal particles has been accumulated and sends a signal to the ECB.

AIR/OIL SEPARATOR

The oil reservoir is vented through an air/oil separator to the exhaust cone. When the APU operates, the air/oil separator extracts the oil from the air drawn from the lubrication scavenge pump. Once the separation is completed, the remaining air is vented through the gearbox vent line. The air/oil separator is not an LRU. All these systems are the gearbox accessories.

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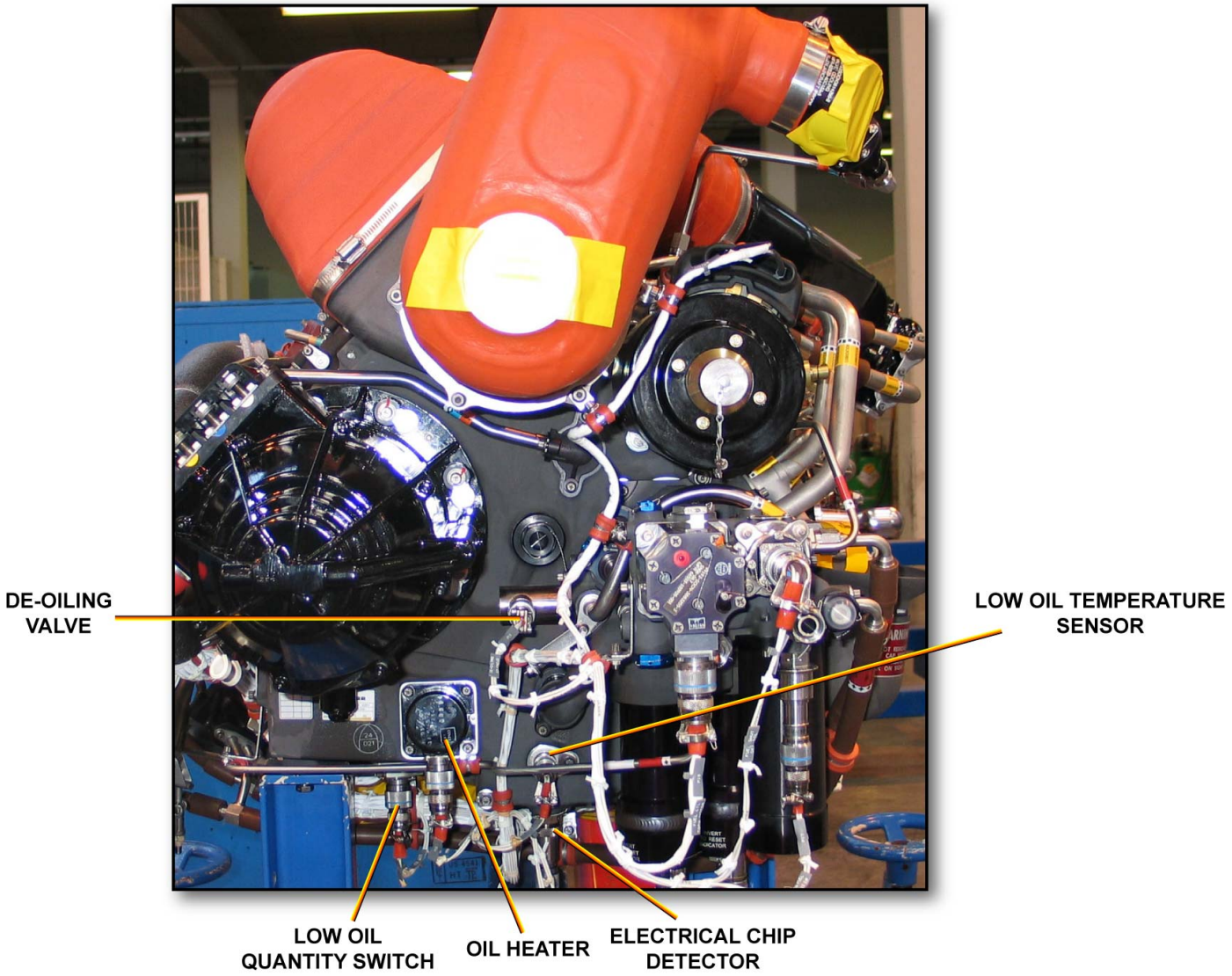
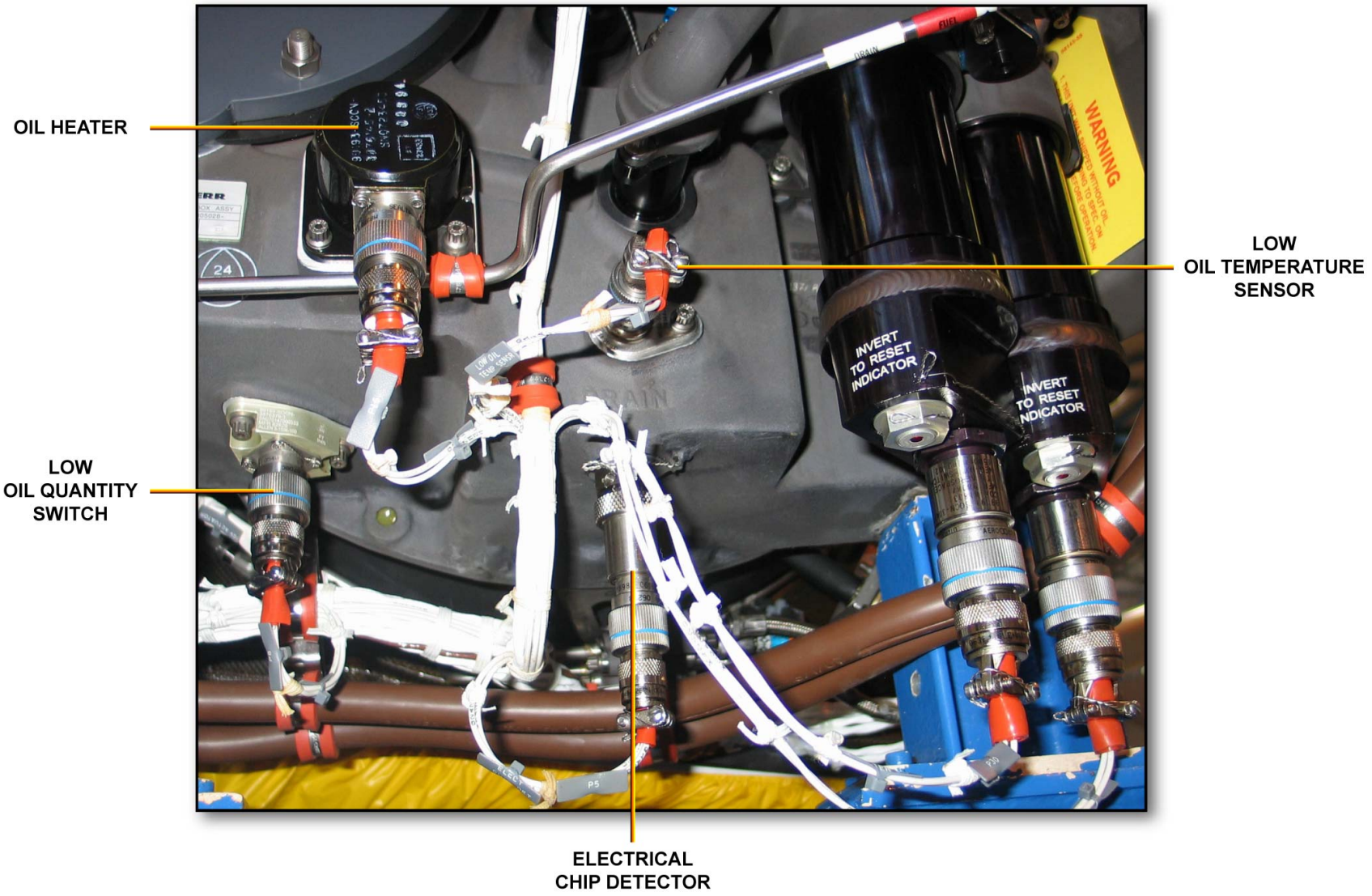


GEARBOX DESCRIPTION - GRAVITY FILLING PORT, PRESSURE FILLING PORT AND OIL OVERFLOW PORT ... AIR/OIL SEPARATOR



GEARBOX DESCRIPTION - GRAVITY FILLING PORT, PRESSURE FILLING PORT AND OIL OVERFLOW PORT ... AIR/OIL SEPARATOR

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APU OIL D/O (3)

OIL COOLER AND THERMAL BYPASS VALVE

The oil cooler and the thermal bypass valve are used to maintain a proper oil temperature during APU operation. The operated Thermal bypass valve operated is fully open at 60°C and fully closed at 77°C.

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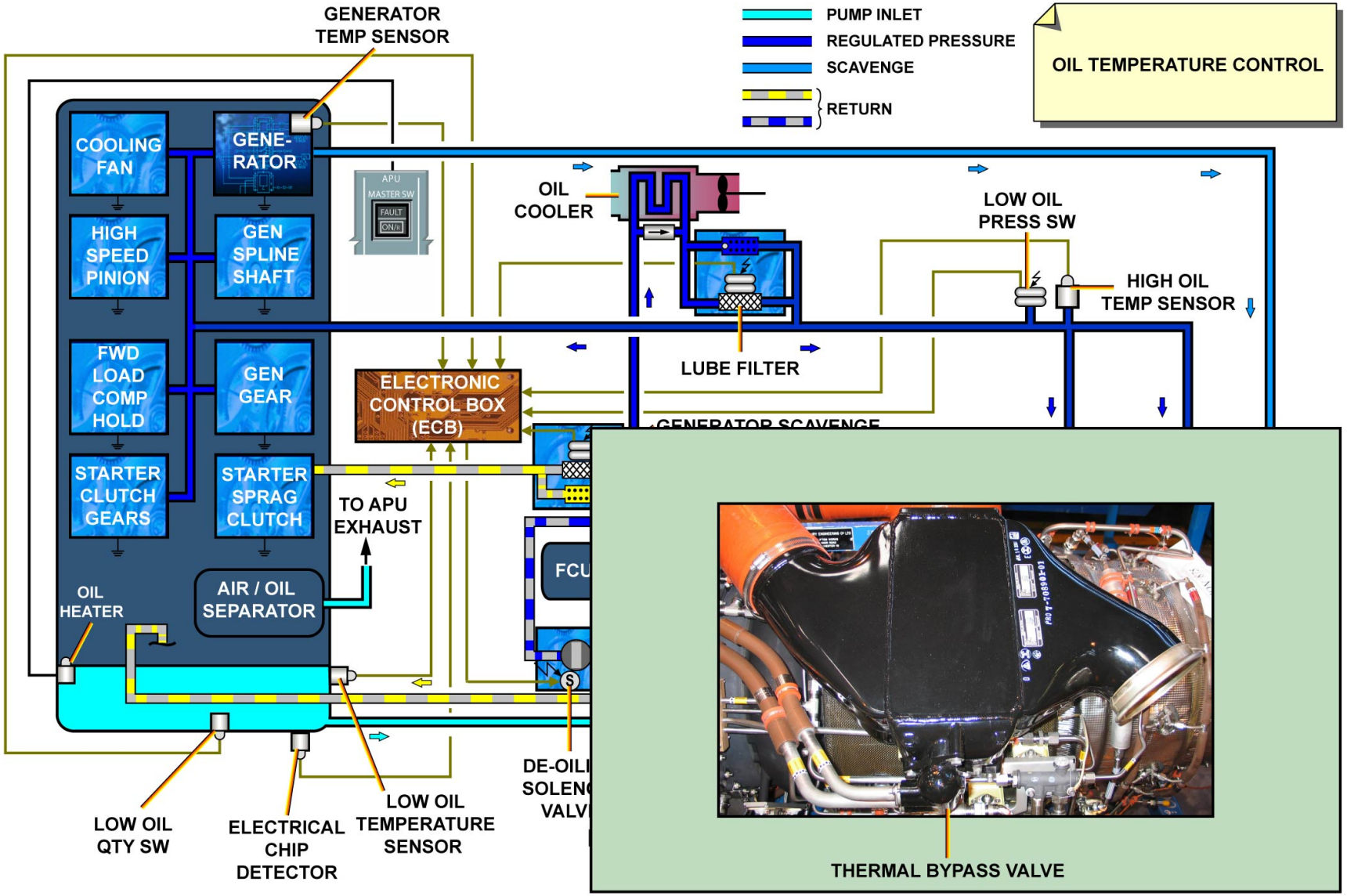

OIL COOLER AND THERMAL BYPASS VALVE

APU OIL D/O (3)

NORMAL OPERATION

In this topic, the normal operation of the oil system will be described through the feed, distribution, scavenge and vent system.
The generator High Oil Temperature (HOT) sensor is installed inside the APU generator. It measures the temperature of the generator scavenge oil. The ECB receives analog signal from this sensor and thus monitors the temperature of the generator scavenge oil.

DISTRIBUTION

Oil is pumped by three gyrotor pump elements in parallel and goes through the oil pressure relief valve located in the lubrication module, which maintains an oil pressure of 65 psig plus or minus 5 psi.
Then, oil goes through the thermal bypass valve.
If the oil temperature is less than 60°C, the valve sends the oil directly to the lube filter.
If the oil temperature is more than 60°C, the thermal bypass valve starts to close and the oil goes through the oil cooler before going into the lube filter. If the oil temperature is more or equal to 77°C the valve is fully closed.
Finally, oil is supplied to the lubrication points of:
- the APU turbine and mid-frame bearings,
- the load compressor,
- the accessory drive gearbox,
- the APU generator.

During APU start, the de-oiling solenoid valve will be energized opening in the cold condition.

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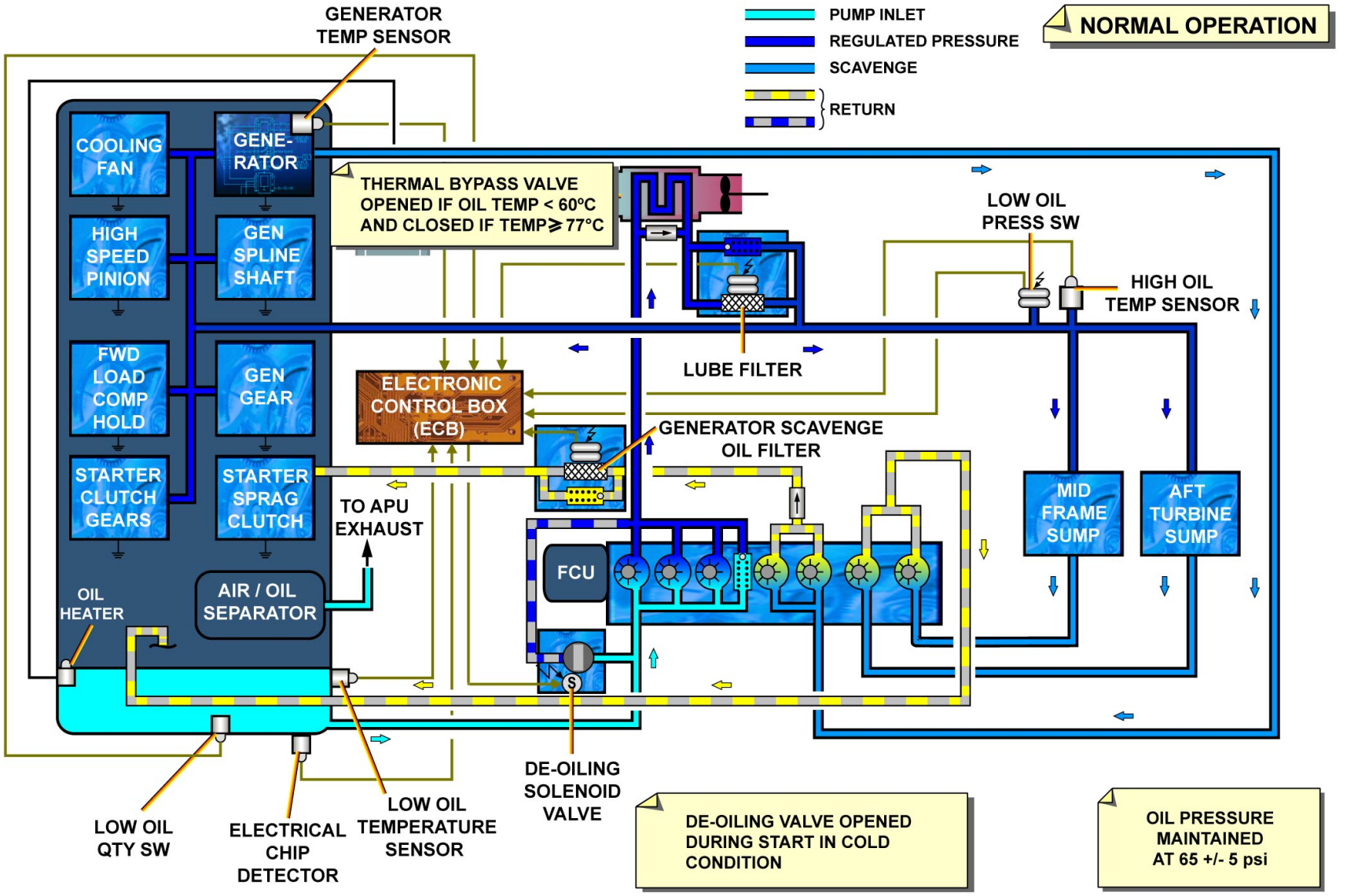

NORMAL OPERATION - DISTRIBUTION

GCL13151 - GEHT0M0 - FM49D200000003

APU OIL D/O (3)

NORMAL OPERATION (continued)

SCAVENGE

The APU generator scavenge oil is picked up by three pump elements and passed through a dedicated filter element. This prevents any debris from the generator to be carried to the APU. Then, oil lubricates the starter before going back to the gearbox sump. The oil from the APU mid-frame and turbine bearings is scavenged to the oil reservoir by two gyrotor pump elements and is sent back to the gearbox sump.

OIL VENT

Oil scavenged from the oil sumps is highly contaminated by air, which leaks through the carbon face seals. Consequently, a greater volume of air and oil mixture flows through the scavenge pump elements and enters the gearbox. The air/oil separator extracts the air from the mixture and sends it outside through the exhaust duct.

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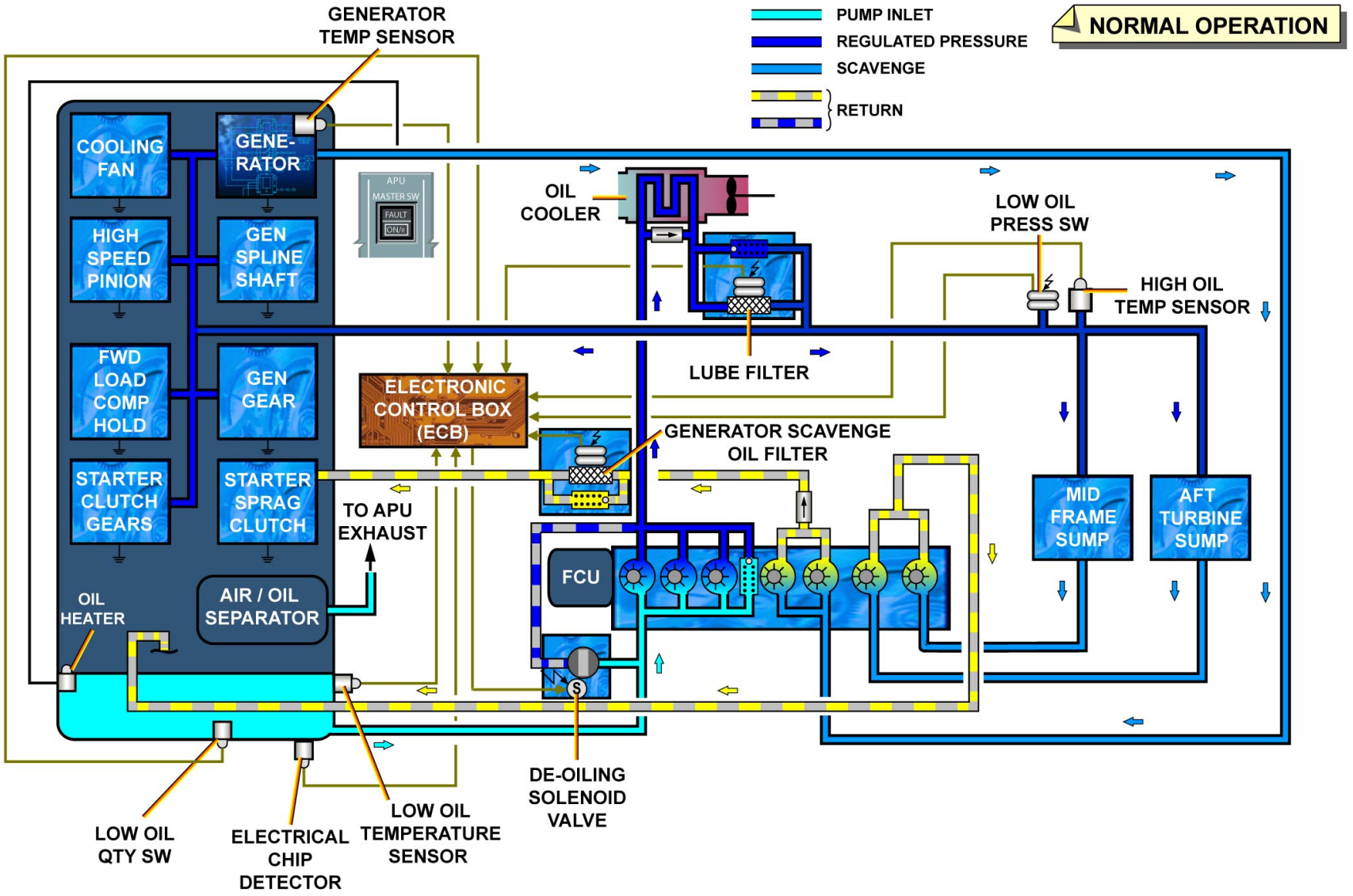

NORMAL OPERATION - SCAVENGE & OIL VENT

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APU OIL D/O (3)

ABNORMAL OPERATION

The LOP and High Oil Temperature (HOT) warning systems protect the APU against malfunctions, which may seriously damage the APU.

LOP CONDITION

If the oil pressure decreases to 28 psi plus or minus 2 psi, the LOP switch transmits a low oil-pressure signal to the ECB which triggers an APU shutdown.

NOTE: During the flight, the LOP shutdown is inhibited.

HOT CONDITION

Two HOT shutdowns can be initiated by the ECB:
- if the temperature measured by the oil temperature sensor is higher than 147°C, for more than 10 seconds, the ECB triggers a HOT APU shutdown,
- if the temperature measured by the generator oil temperature sensor is higher than 185°C, for more than 1 second, the ECB triggers an APU generator HOT shutdown.

NOTE: During the flight, the HOT shutdown is inhibited.

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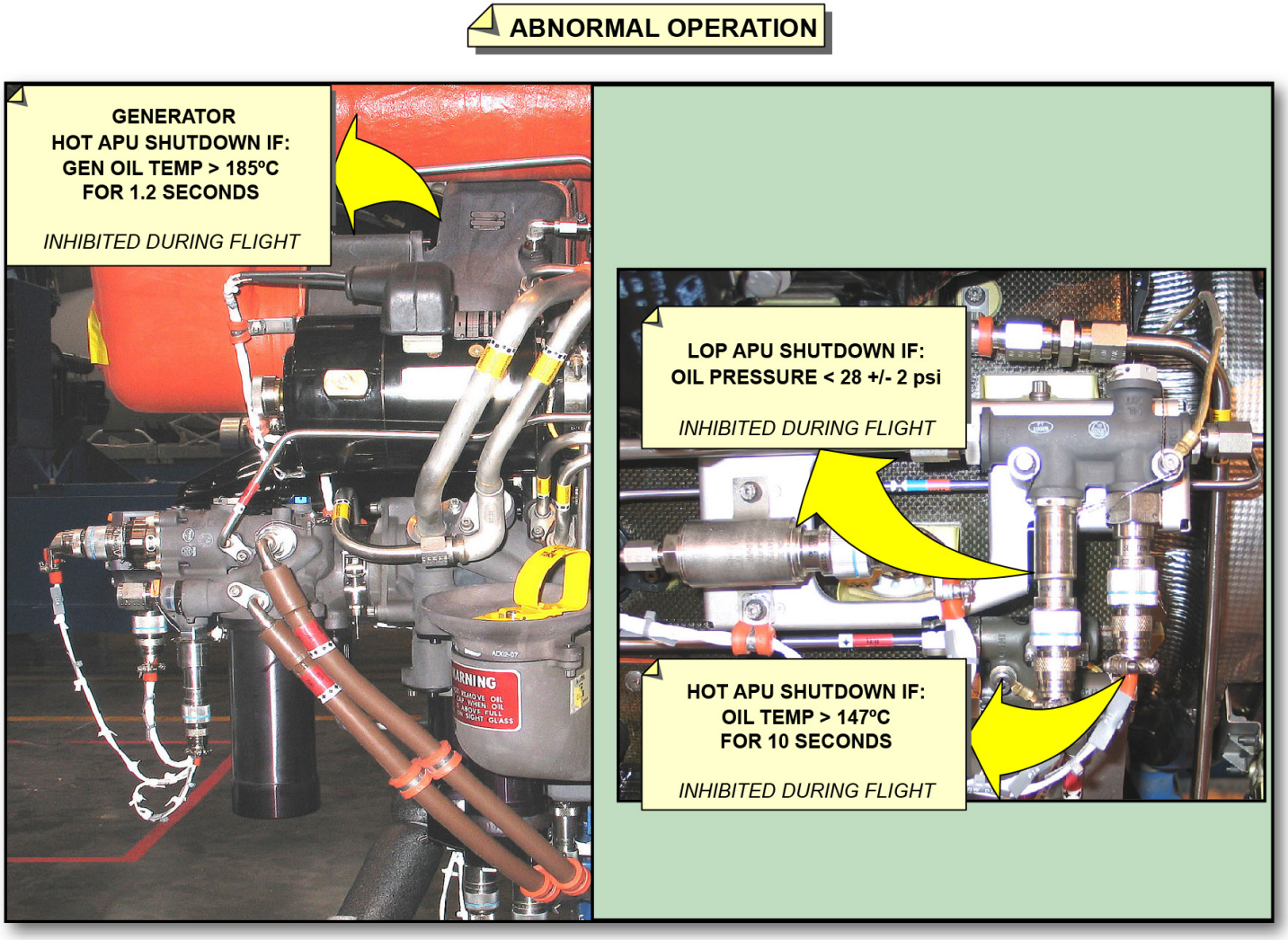

ABNORMAL OPERATION - LOP CONDITION & HOT CONDITION

APU OIL D/O (3)

MONITORING

The ECB monitors the oil level status when the aircraft is on ground; the APU is not running and when the power-up initialization is finished, a few seconds after the APU master switch is pressed in.
Three conditions of the oil level are shown on the EIS and on the Centralized Maintenance System (CMS):
- if an OIL LEVEL: OK indication is displayed on the APU SERVICE DATA page of the CMS, and if no indication is displayed on the ECAM APU page, the oil level is sufficient.
- if an OIL LEVEL: CHECK indication is displayed on the APU SERVICE DATA page of the CMS, and if a CHECK OIL LEVEL message appears on the ECAM APU page, the oil level lets the APU operate for 60 hours with a oil quantity of about 4 liters.

NOTE: : This CHECK OIL Level is triggered when oil level is only at 0.7 QT above the ADD / LOW OIL Level .

- finally, if an OIL LEVEL: LOW indication is displayed on the APU SERVICE DATA page of the CMS, and if a LOW OIL LEVEL message appears on the ECAM APU page, the oil level is less than its minimum and the APU oil reservoir needs to be refilled.

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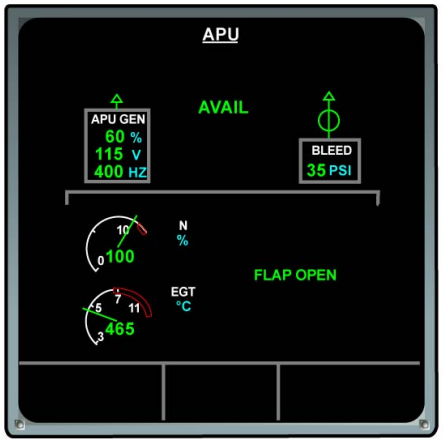
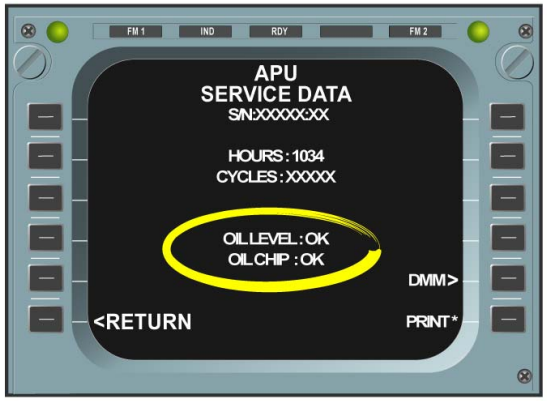
THE OIL LEVEL IS SUFFICIENT



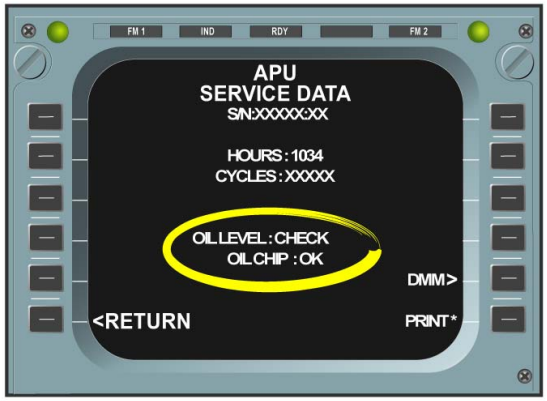
ECAM APU PAGE



CMS APU SERVICE DATA PAGE

THE OIL LEVEL ALLOWS AN APU OPERATION FOR 60 HOURS

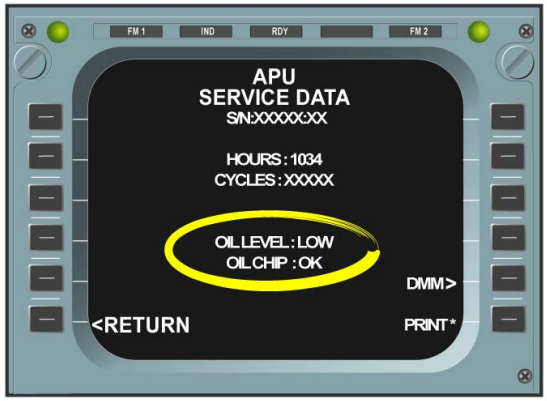
ECAM APU PAGE



CMS APU SERVICE DATA PAGE

THE OIL LEVEL IS AT ITS MINIMUM

ECAM APU PAGE



CMS APU SERVICE DATA PAGE

MONITORING

APU OPERATION, IGNITION AND STARTING D/O (3)

B2 SCOPE

CAUTION: MODULE TAGGED B2 SCOPE.
BE AWARE THAT ONLY AVIONICS/ELECTRICAL TOPICS SHOULD BE LEARNED FOR A T2 COURSE.

DESCRIPTION

The main components of the ignition and starting system are:
- the starter motor and clutch,
- the main and backup contactors,
- the ignition unit,
- the ignition leads,
- the igniter plugs,
- the speed sensors,
- the Exhaust Gas Temperature (EGT) thermocouples,
- the data memory module,
- the Electronic Control Box (ECB).

STARTER MOTOR AND CLUTCH

The starter motor is a series-wound DC motor with an overspeed protection. It is attached to the Auxiliary Power Unit (APU) gearbox by a V-clamp. The starter motor is equipped with a green brushwear indicator. The brushes are serviceable when the indicator is visible. If the green indicator pin disappears, the starter motor must be replaced.
A square end is installed on the shaft of the motor to manually turn the APU.
A starter clutch is used for the mechanical connection via spring-loaded sprags.

MAIN / BACKUP CONTACTORs

The main start contactor is installed in the APU box, and the backup start contactor is installed in a box located in the aft underfloor compartment, in the waste tank area. These two heavy-duty contactors supply the starter motor with 28V DC.

IGNITION UNIT

The ignition unit is installed on the lower RH side of the APU in a hermetically sealed container. The ignition unit is connected to the ECB for control and to both igniter plugs to supply the required high voltage electrical pulses.
The ignition unit operates on 14 to 36V DC input voltage, and creates an output voltage greater than 18,000 V at a minimum spark rate of 2 sparks per second.

IGNITION LEADS

The ignition leads have Teflon-insulated ignition wire covered with a flexible tube of spirally-wound nickel-iron alloy and an outer stainless-steel braid. The ignition leads ensure the connection between the ignition unit and each igniter plug.

IGNITER PLUGS

Each igniter plug has:
- the electrode,
- the insulator,
- the two-piece outer shell.

The igniter plugs ignite the fuel/air mixture in the combustion chamber.

SPEED SENSORS

The speed sensors are installed between the load compressor and the air intake housing. Each of the speed sensors measure the APU speed and transmits a frequency to the ECB.

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EXHAUST GAS TEMPERATURE (EGT) THERMOCOUPLES

Four thermocouples are installed in the exhaust cone at the turbine discharge. Each thermocouple is a chrome-alumel device with two probes of different length. Two thermocouple devices are connected together, forming two separate thermocouple rakes. Each thermocouple rake is connected to the ECB.

MEMORY MODULE

The memory module is a digital memory device, mounted on the left side of the inlet plenum. The memory module is used to store information regarding the health monitoring and life usage of the APU.

The memory module interfaces with the ECB and stores the following information:

- APU serial number,
- APU operating hour,
- number of successful starts,
- number of unsuccessful starts,
- turbine life consumed.

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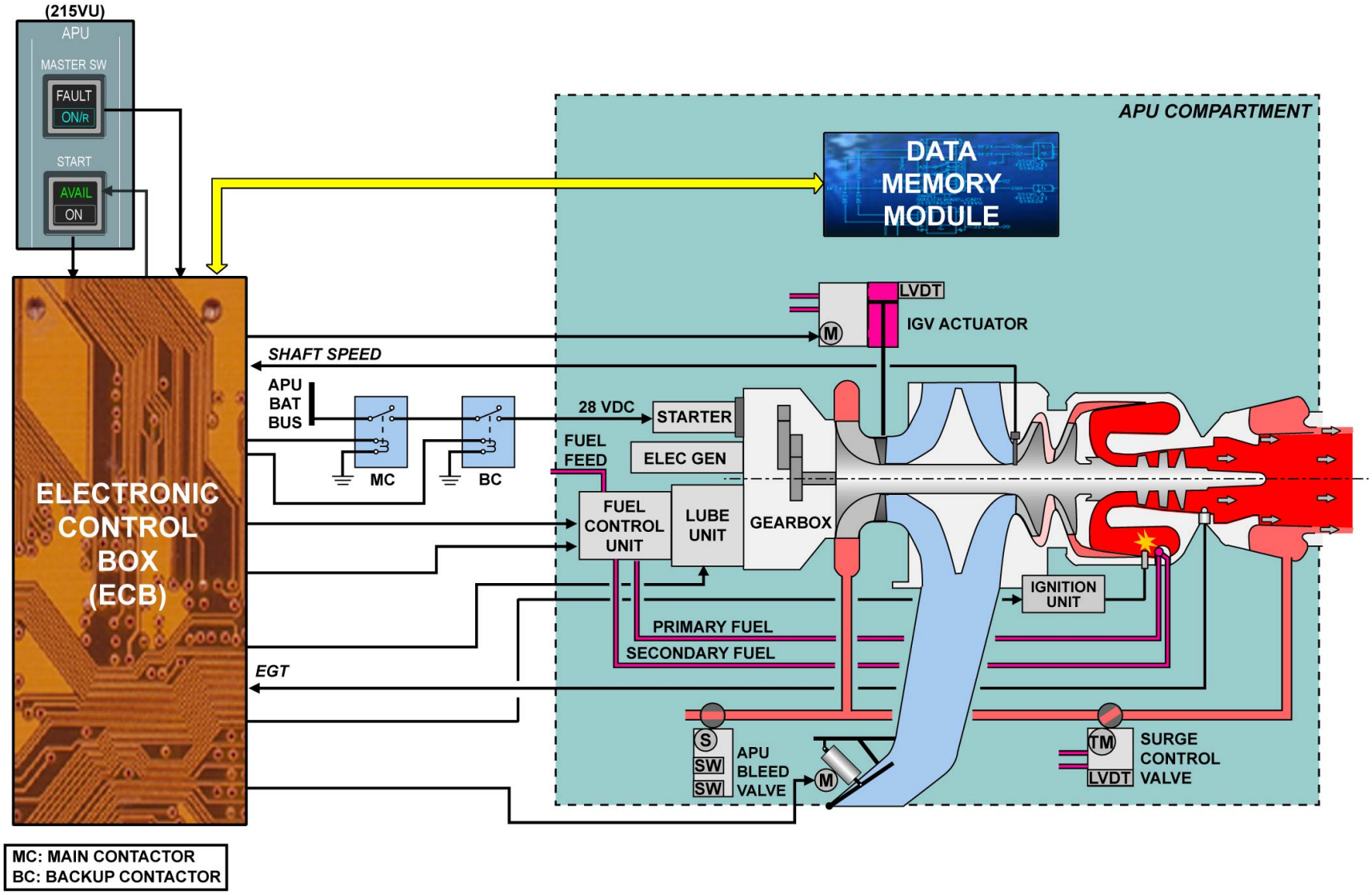

B2 SCOPE & DESCRIPTION

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APU OPERATION, IGNITION AND STARTING D/O (3)

DESCRIPTION (continued)

ELECTRONIC CONTROL BOX (ECB)

The ECB is a microprocessor-based digital electronic controller that is the primary part of the APU system logic. In addition to controlling the APU, the ECB has an integral BITE capability specifically incorporated to shorten diagnostic operations for troubleshooting.
The main interfaces to the ECB are:
- the APU control P/Bs on the overhead panel,
- the bleed and surge air system,
- the Environmental Control System (ECS),
- the Ground Control Unit (GCU),
- the Central Maintenance System (CMS),
- the memory module,
- the APU actuators, sensors and probes,
- the EIS,
- the Aircraft Condition Monitoring System (ACMS).

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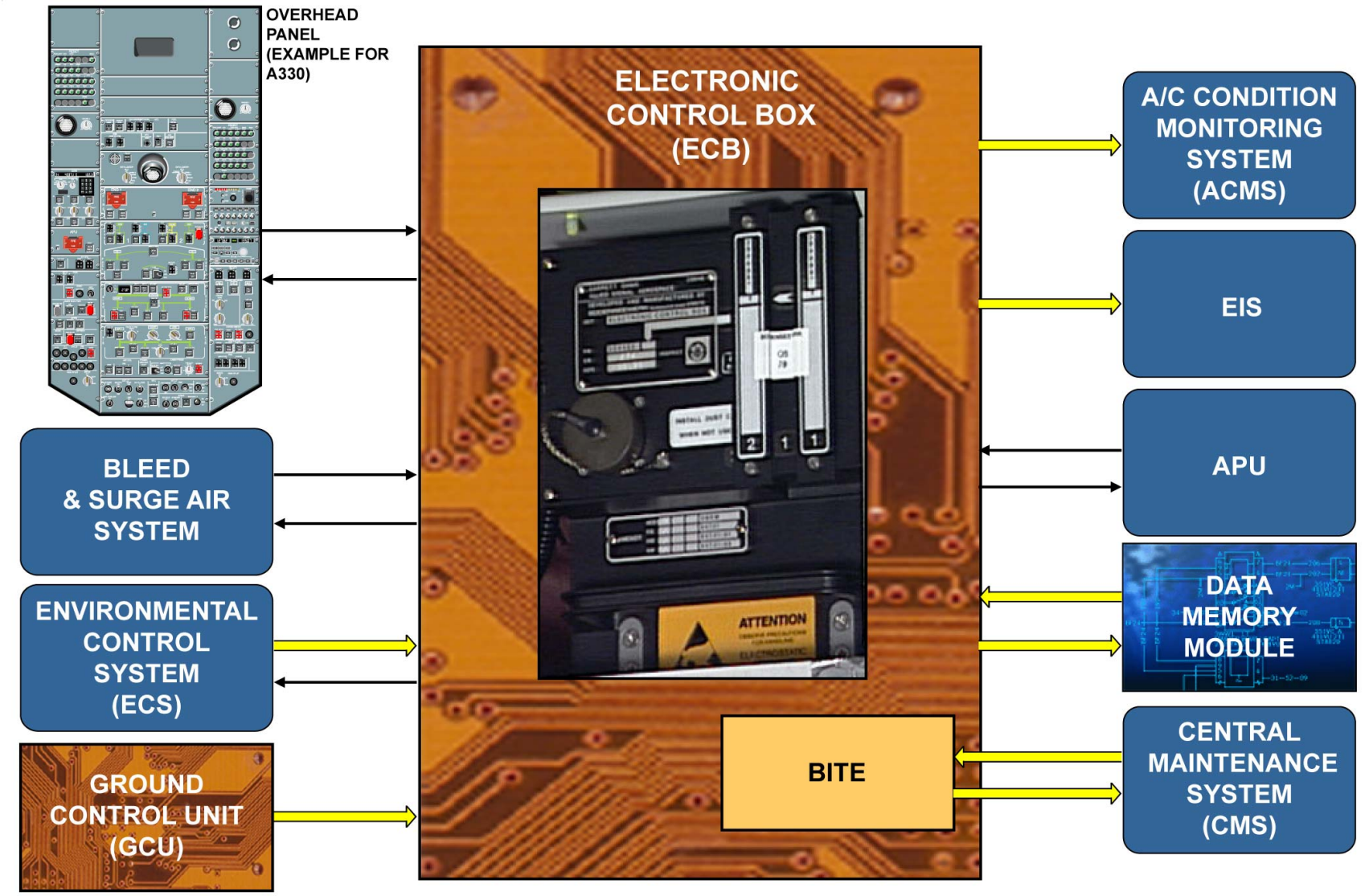

DESCRIPTION - ELECTRONIC CONTROL BOX (ECB)

APU OPERATION, IGNITION AND STARTING D/O (3)

APU START OPERATION

The starting sequence is divided into two parts:
- the start initialization via the APU MASTER SWitch,
- starting the APU starter motor via the START P/BSW.

MASTER SWITCH ON

When the MASTER SWitch is set to ON, the ECB is electrically supplied and the following sequence occurs:
- the ON/R light comes on,
- the APU page is automatically displayed on ECAM, but with only amber crosses,- the ECB starts a power up test and checks the condition of all necessary items,

After a successful power up test of the ECB, the following sequence occurs:
- the APU parameters are normally displayed in green on ECAM,
- the APU fuel feed line is pressurized,
- the air intake flap actuator opens,
- the Inlet Guide Vanes (IGVs) receive a signal for closure,

Then, once the inlet flap is fully open, the FLAP OPEN message appears on the ECAM APU page and the APU is ready to be started.

START P/BSW ON

When the START P/B is set to ON:
- the ON light on the P/B comes on,
- the de-oiling solenoid valve, used to unload the lube pump, opens if required,
- the start contactors close and energize the starter motor,.

Then, APU speed (N) increases.
When APU speed reaches 7%, the ECB energizes the ignition system, opens the fuel solenoid Shut-Off Valve (SOV) and the Fuel Metering Valve (FMV) starts to regulate the fuel flow.
When APU speed is around 50%, the ECB opens the start contactors to de-energize the starter motor and cuts off the ignition.
At 60%, the de-oiling valve closes if it was open.

APU AVAILABLE

When APU speed reaches 95%, the ON light on the START P/B goes off, the AVAIL light comes on in green, the AVAIL message appears on the ECAM APU page and an APU AVAIL message appears on the ECAM EWD memo.
100% is the APU governed speed. The ECB switches to this schedule by regulating the fuel flow in the Fuel Control Unit (FCU). The APU generator can be used and the APU BLEED can be switched on.
The ECB compensates the electrical and pneumatic load effects on speed, by acting on the fuel flow to maintain an APU constant speed at 100%.

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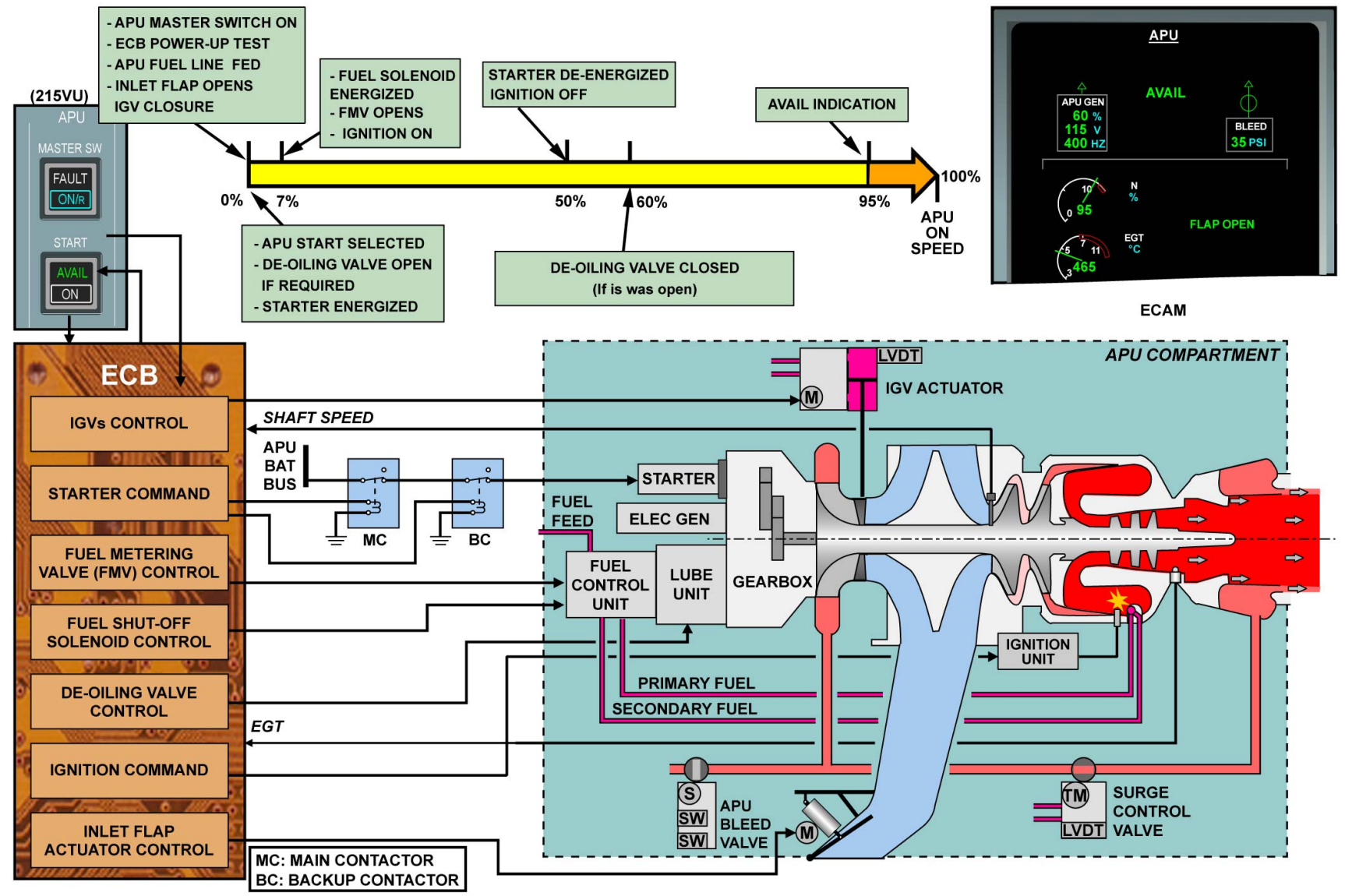


APU START OPERATION & APU AVAILABLE

GCL13151 - GEHT0M0 - FM49D500000003

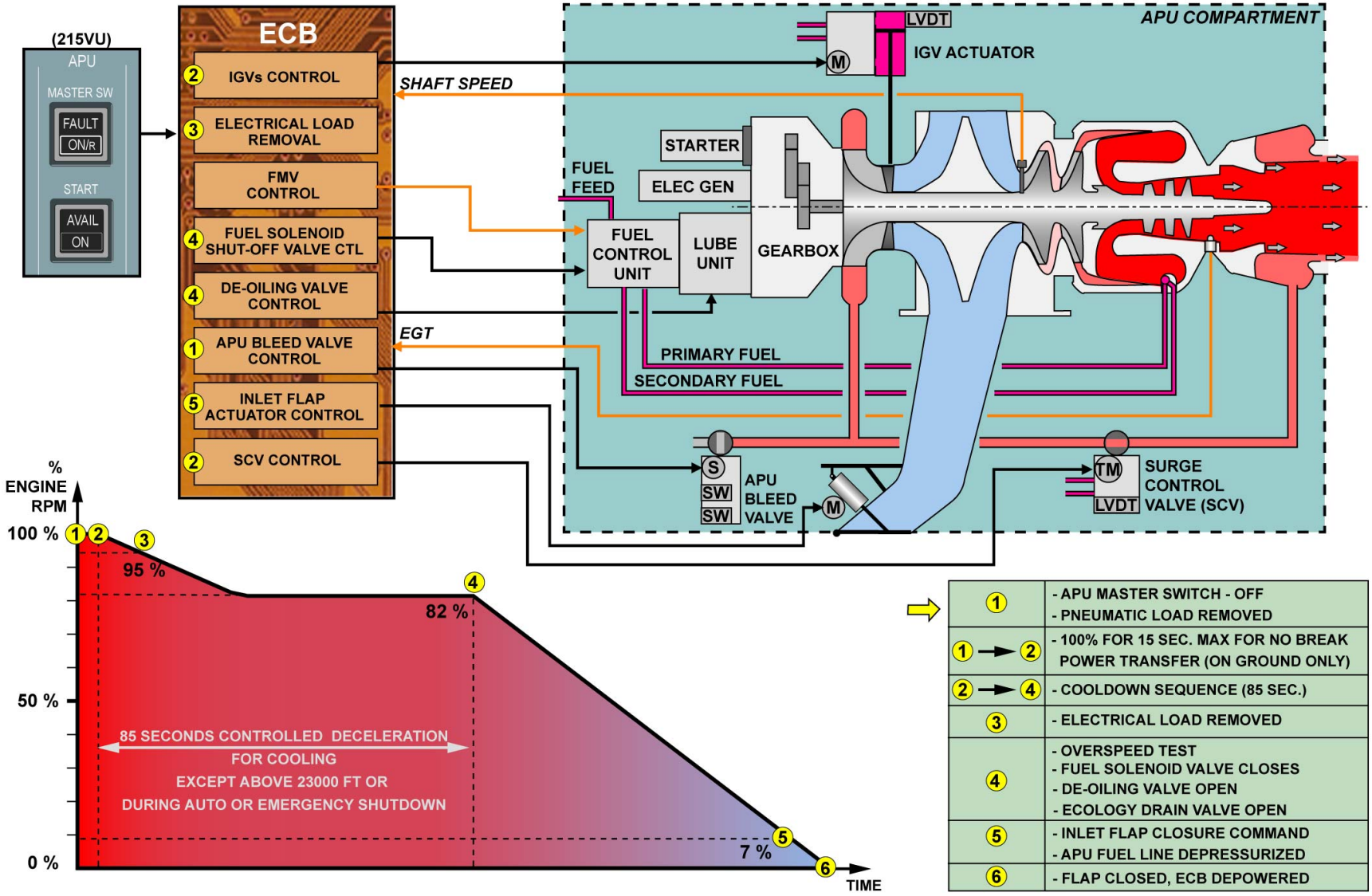
APU OPERATION, IGNITION AND STARTING D/O (3)

NORMAL APU SHUTDOWN

A normal APU shutdown is initiated when the APU MASTER SW is set to OFF.
Once the shutdown sequence is initiated, the pneumatic load is removed by the ECB by closing the IGVs, opening the surge control valve and closing the APU bleed valve if it was not already closed.
On ground only, the APU will remain at 100% speed for approximately 15 seconds to allow electrical source synchronization for no-break power transfer.
Then, APU speed decreases down to 82% for a 85 seconds cool down period. This cool down period is only initiated if the A/C is below 23,000 feet and for a normal shutdown sequence.
During the entire cool down period the IGVs are closed and the surge control valve is open.
When APU speed decreases below 95%, the AVAIL legend goes off on the START P/BSW.
At the end of the cool down period, the ECB sends an overspeed signal in order to test the overspeed protection circuit and by this way to shutdown the APU. The fuel solenoid SOV is closed, the de-oiling valve is open to return the oil to the sump, and the ecology drain valve is open to blow out the residual fuel from the fuel manifold. In this mode no protective shutdown is recorded by the ECB.
When the speed has decreased down to 7%, the following sequence is controlled by the ECB:
- de-oiling solenoid valve is closure,
- ecology drain valve closure,
- inlet flap starts to close,
- APU fuel feed line is depressurized.

During APU roll down, APU re-start is possible if the MASTER SWitch is set to ON again under the condition that speed is still above 7%.
Once the inlet flap has reached its fully closed position, the ECB is self-de-powered and all indications on the APU page change to amber crosses. Data related to the last run of the APU is transmitted to the memory module.

GCL13151 - GEHT0M0 - FM49D500000003



NORMAL APU SHUTDOWN

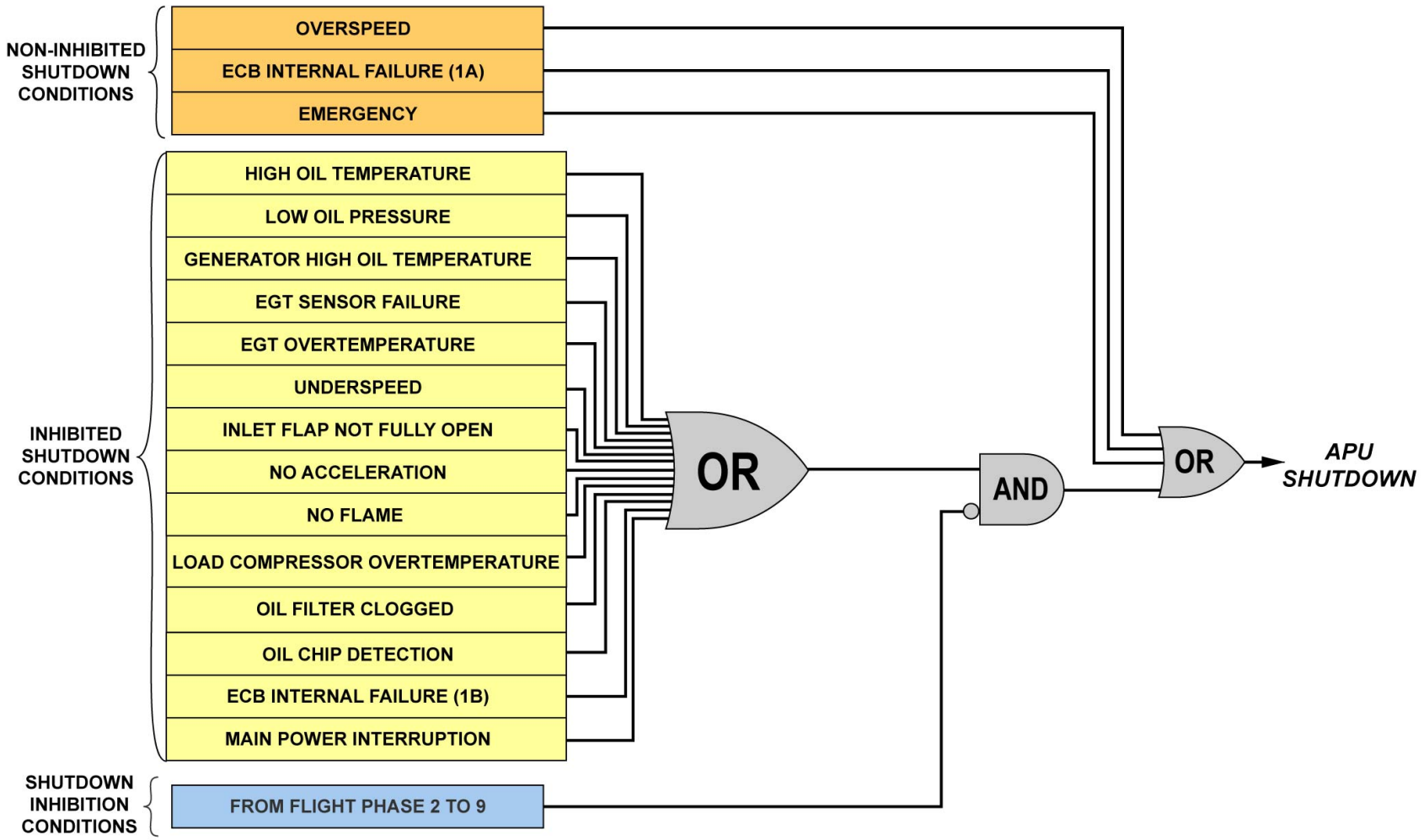
GCL13151 - GEHT0M0 - FM49D500000003

APU OPERATION, IGNITION AND STARTING D/O (3)

PROTECTIVE SHUTDOWNS

A protective shutdown logic shuts down the APU automatically whenever continued APU operation would result in damage to the A/C, the APU or the ECB. The shutdown sequence is the same as the normal shutdown sequence except that there is no 85 seconds cooling period.
Three shutdown conditions are active at all times:
- the overspeed shutdown, when APU speed reaches 107%,
- the ECB significant internal failure (1A) shutdown, such as:
- loss of overspeed protection,
- CPU or RAM CPU or EPROM CPU failure,
- CPU power supply failure, ...
- the emergency shutdown triggered by:
- the APU fire and overheat detection system (only on ground),
- the APU FIRE P/BSW on the overhead panel,
- the APU SHUT OFF P/BSW, on the external power control panel, at the fuselage near the NLG,
- the APU EMERG SHUTDOWN P/BSW on the refuel/defuel panel at the belly fairing.
The other shutdown conditions are inhibited from the start of the first engine to the shutdown of the last engine (i.e. from flight phase 2 to 9).
These shutdown conditions are:
- High Oil Temperature (HOT), when the oil temperature is above 147°C (297 °F),
- Low Oil Pressure (LOP),
- Generator High Oil Temperature shutdown, when the temperature is above 185°C (365 °F),
- EGT sensor failure: i.e. loss of EGT signal (failure of both thermocouple rakes),
- EGT overtemperature, when EGT exceeds 1,260°C (2,300 °F) during start or exceeds 1,232°C (2,250 °F) during on-speed operation,
- underspeed: i.e. speed dropping below 88% when APU is on-speed,
- inlet flap not fully open,
- no acceleration: insufficient acceleration rate
- no flame: EGT remains below 205 °C (400 °F) for 30 seconds during start sequence.
- load compressor overtemperature:
. load compressor inlet temperature (T2) is above 177°C (350 °F),
. load compressor outlet temperature is above 250°C (480 °F),
. reverse flow condition,
. surge control valve abnormal position,
- oil filter clogged: lube filter or/and generator scavenge oil filter differential pressure switch is closed (clogging condition) with oil temperature above 38 °C (100 °C).
- oil chip detection
- ECB internal failure (1B): 15 VDC power supply failure or power supply monitoring failure
- main power interrupt above 0.5 second while APU is running
The cause of APU auto-shutdown is stored in the ECB memory.

GCL13151 - GEHT0M0 - FM49D500000003



PROTECTIVE SHUTDOWNS

GCL13151 - GEHT0M0 - FM49D500000003

APU SYSTEM OPERATION, CONTROL & INDICATING (3)

APU AUTO SHUTDOWN

EMERGENCY SHUT-DOWN

ANIMATED SCHEMATIC

GCL13151 - GEHT0M0 - FM49IZLEVEL0301

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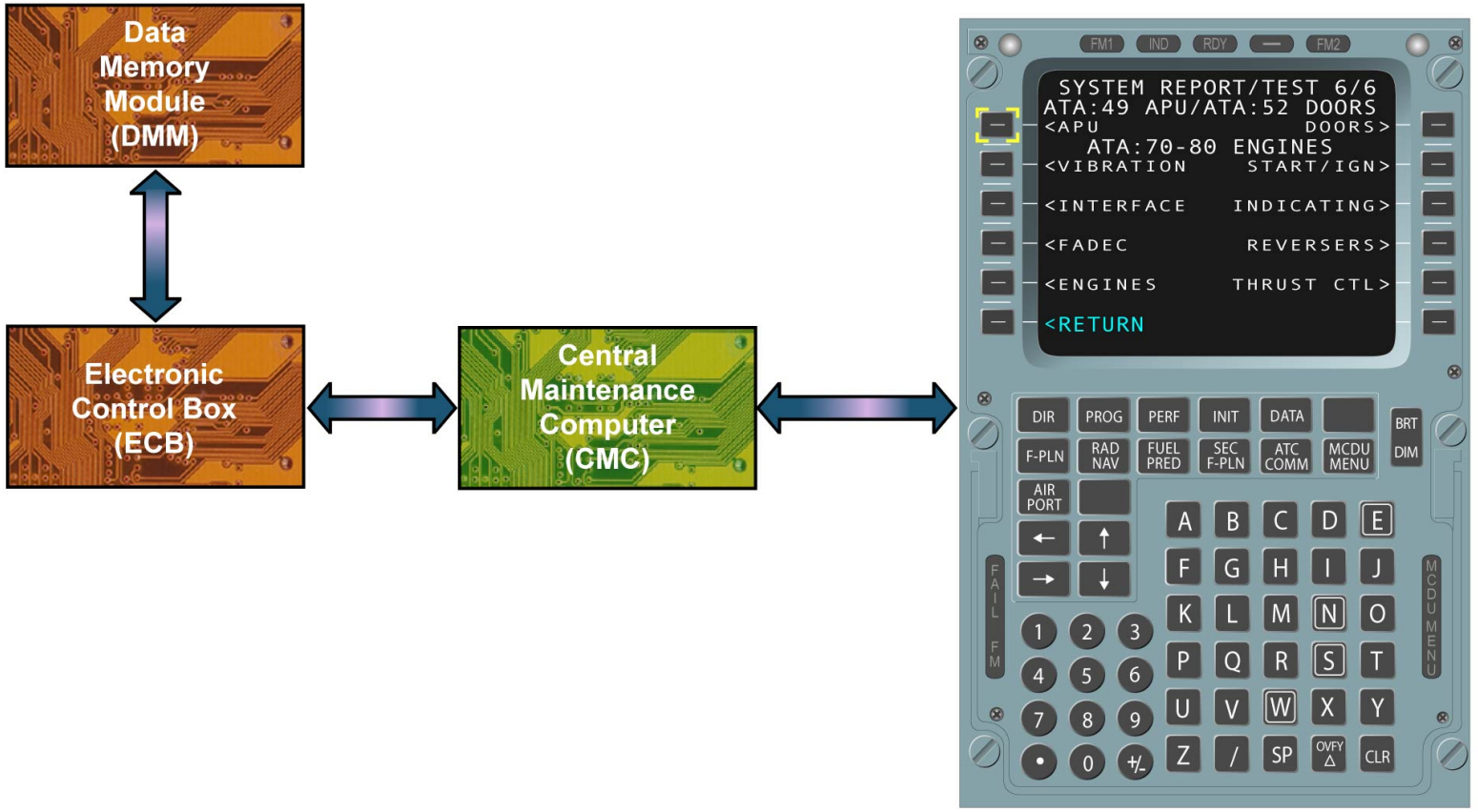
GCL13151 - GEHT0M0 - FM49IZLEVEL0301

APU MCDU PAGES (2)

GENERAL

The Auxiliary Power Unit (APU) system architecture is built around the Electronic Control Box (ECB). It is a TYPE 1 computer.
The Data Memory Module (DMM) of the APU stores information on the APU life. It is linked to the ECB.
The maintenance message consultation is performed from the MCDU through two Central Maintenance Computer (CMC).
The SYSTEM REPORT/TEST page 6/6 of the Central Maintenance System (CMS) ground menu gives access to an interactive mode which allows APU system data retrieving and tests initiation.

GCL13151 - GEHT0M0 - FM49P2MCDUTST02


Data Memory Module (DMM)
Electronic Control Box (ECB)
Central Maintenance Computer (CMC)
FM1
IND
RDY
FM2
SYSTEM REPORT/TEST 6/6
ATA:49 APU/ATA:52 DOORS
<APU DOORS>
ATA:70-80 ENGINES
<VIBRATION START/IGN>
<INTERFACE INDICATING>
<FADEC REVERSERS>
<ENGINES THRUST CTL>
<RETURN
DIR
PROG
PERF
INIT
DATA
F-PLN
RAD NAV
FUEL PRED
SEC F-PLN
ATC COMM
MCDU MENU
BRT
DIM
AIR PORT
FAIL FM
MCDU MENU
OVFY
CLR
SP

GENERAL

APU MCDU PAGES (2)

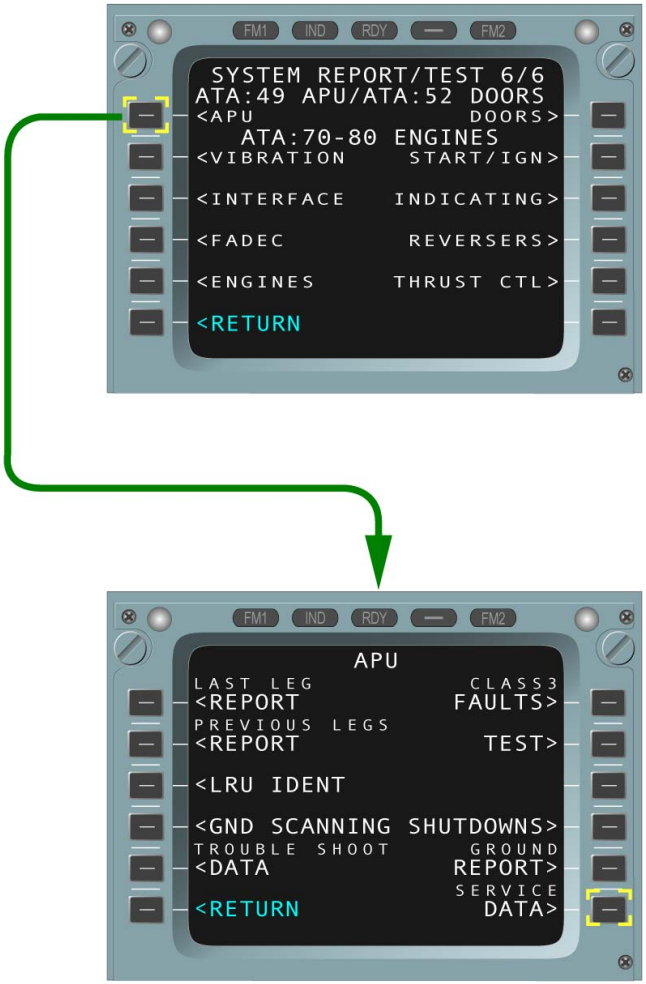
APU SYSTEM DATA AND TESTS

The APU line key of the SYSTEM REPORT/TEST page 6/6 gives access to the APU menu page.
Three specific functions can be used for APU data retrieving or testing:
- TEST,
- SHUTDOWNS,
- SERVICE DATA.

The TEST line key is used to carry out an ECB POWER UP TEST or an ECB SELF TEST, depending on the ECB mode (COMMUNICATION or RUN mode).
The SHUTDOWNS line key gives access to the data concerning the APU shutdowns occurring during the last 63 flight legs.
It shows:
- the fault date,
- the fault time,
- the Fault Code Number (FCN),
- the shutdown cause,
- the fault message from the concerned Line Replaceable Unit (LRU),
- the shutdown reason,
- the flight phase.

The SERVICE DATA line key gives access to general service data of the APU.
It shows:
- the APU serial number,
- the APU total operation hours,
- the number of APU starts,
- the oil level status,
- the oil chip detector status,
- the trend of the Exhaust Gas Temperature (EGT),
- it enables access to the data stored in the DMM.

GCL13151 - GEHT0M0 - FM49P2MCDUTST02



TEST LINE KEY:

- ECB POWER UP TEST OR SELF TEST

SHUTDOWNS LINE KEY:
(LAST 63 FLIGHT LEGS)

- FAULT DATE
- FAULT TIME
- FAULT CODE NUMBER (FCN)
- SHUTDOWN CAUSE
- FAULT MESSAGE FROM LRU
- SHUTDOWN REASON
- FLIGHT PHASE

SERVICE DATA LINE KEY:

- APU SERIAL NUMBER
- OPERATION HOURS
- APU STARTS
- OIL LEVEL STATUS
- OIL CHIP DETECTOR
- TREND OF EGT
- DATA MEMORY MODULE (DMM) DATA

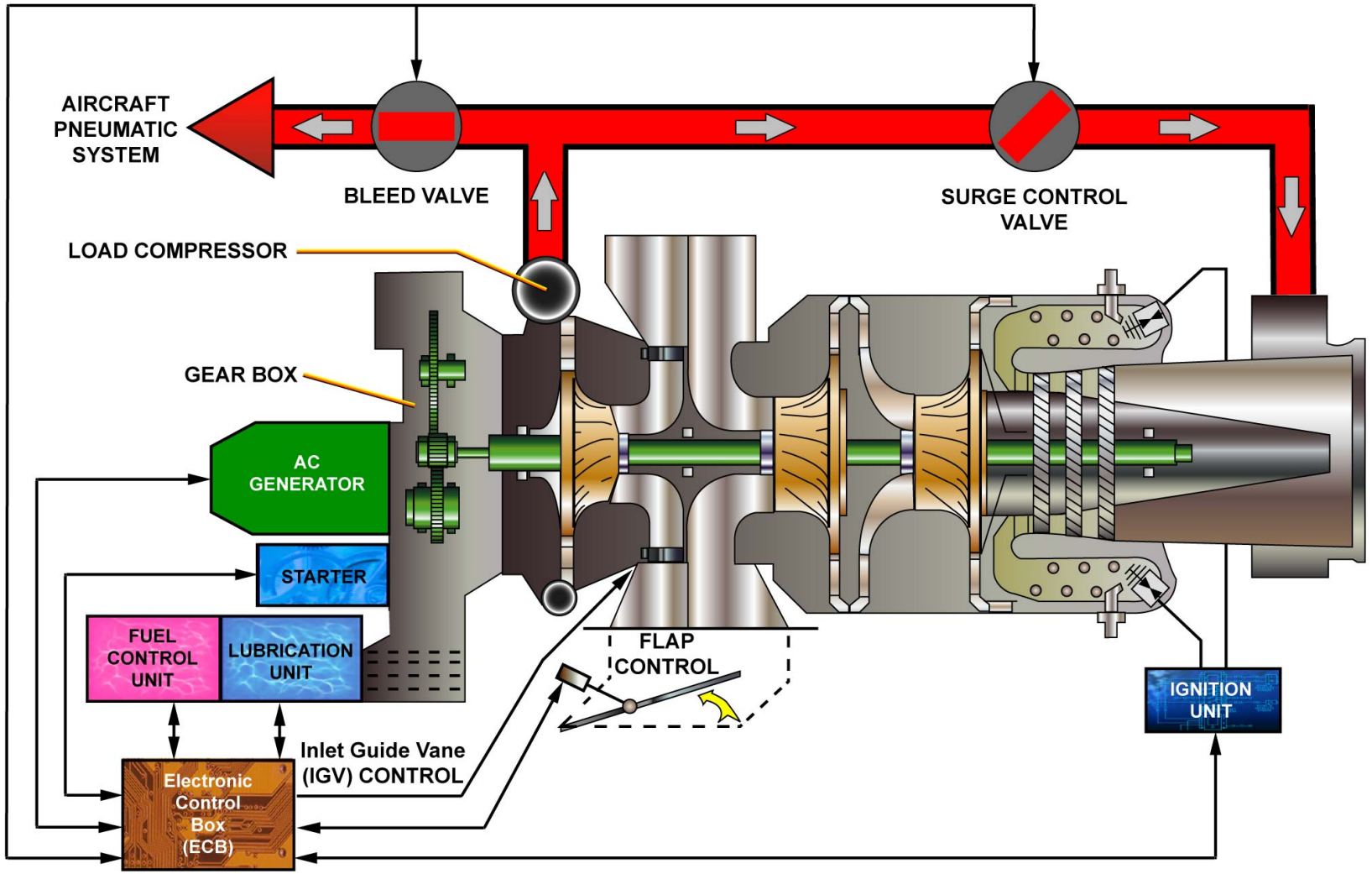
APU SYSTEM DATA AND TESTS

APU SYSTEM LINE MAINTENANCE (2)

GENERAL OVERVIEW

The APU is located at the aft fuselage.

GCL13151 - GEHT0M0 - FM49B1000000001



GENERAL OVERVIEW

APU SYSTEM LINE MAINTENANCE (2)

SERVICING

APU ACCESS DOOR OPENING & CLOSING

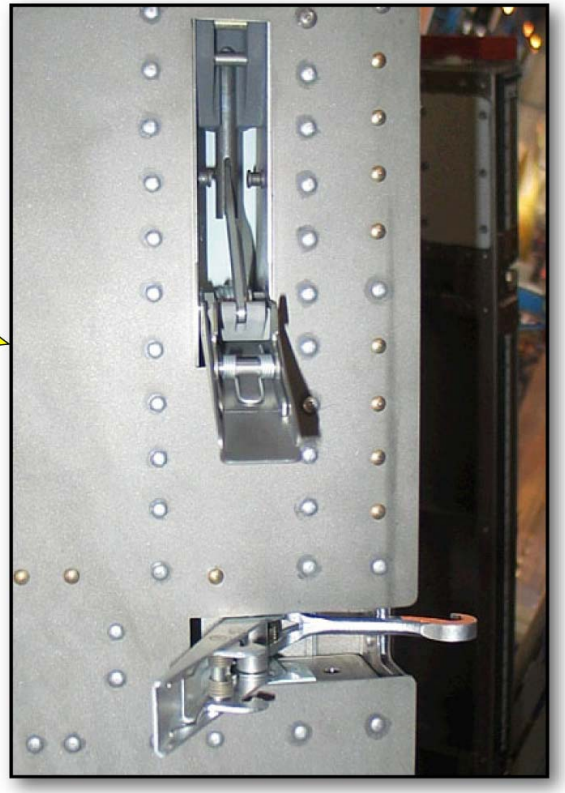
The APU cowl doors are secured with three quick-release hook latches fasteners and four pin latches. The hook latches secure the doors together and the pin latches secure the doors to the aircraft structure.
Procedure to open the doors:
- release 3 hook latches,
- support the door and release the 2 pin latches of each door,
- use support struts to secure the doors.

To close the access doors, release the support struts. Support the doors, close the hook latches and then close the pin latches.

GCL13151 - GEHT0M0 - FM49B1000000001

APU COMPARTMENT

HOOK LATCHES



SERVICING - APU ACCESS DOOR OPENING & CLOSING

SERVICING - APU ACCESS DOOR OPENING & CLOSING

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GCL13151 - GEHT0M0 - FM49B1000000001

APU SYSTEM LINE MAINTENANCE (2)

SERVICING (continued)

APU OIL SERVICING

APU oil servicing is accomplished on an "as-needed" basis or after scheduled oil quantity checks. The ECB monitors the oil level status via the low oil quantity switch when the A/C is on ground, the APU not is not running and when the power-up initialization is finished, a few seconds after the APU MASTER SW is pressed in.
Three conditions of the oil level are represented on the EIS and on the Centralized Maintenance System (CMS):
- if an OIL LEVEL: OK indication is displayed on the APU SERVICE DATA page of the CMS, and if no indication is displayed on the ECAM APU page, the oil level is sufficient.
- if an OIL LEVEL: CHECK indication is displayed on the APU SERVICE DATA page of the CMS, and if a CHECK OIL LEVEL message appears on the ECAM APU page, the oil level allows an APU operation for 60 hours.
- finally, if an OIL LEVEL: LOW indication is displayed on the APU SERVICE DATA page of the CMS, and if a LOW OIL LEVEL message appears on the ECAM APU page, the oil level is at its minimum and the APU oil reservoir needs to be refilled.

The APU LOW OIL LEVEL message agrees with the ADD mark on the oil reservoir (gearbox) sight glass.
SUMMARY of APU OIL quantities for indication on ECAM versus Sight Glass :
- FULL level is at about 3.7 QTs above ADD level ,
- CHECK OIL LEVEL is triggered when oil level is only 0.7 QT above the ADD level ,
- LOW OIL LEVEL is triggered when oil level is at the ADD level.

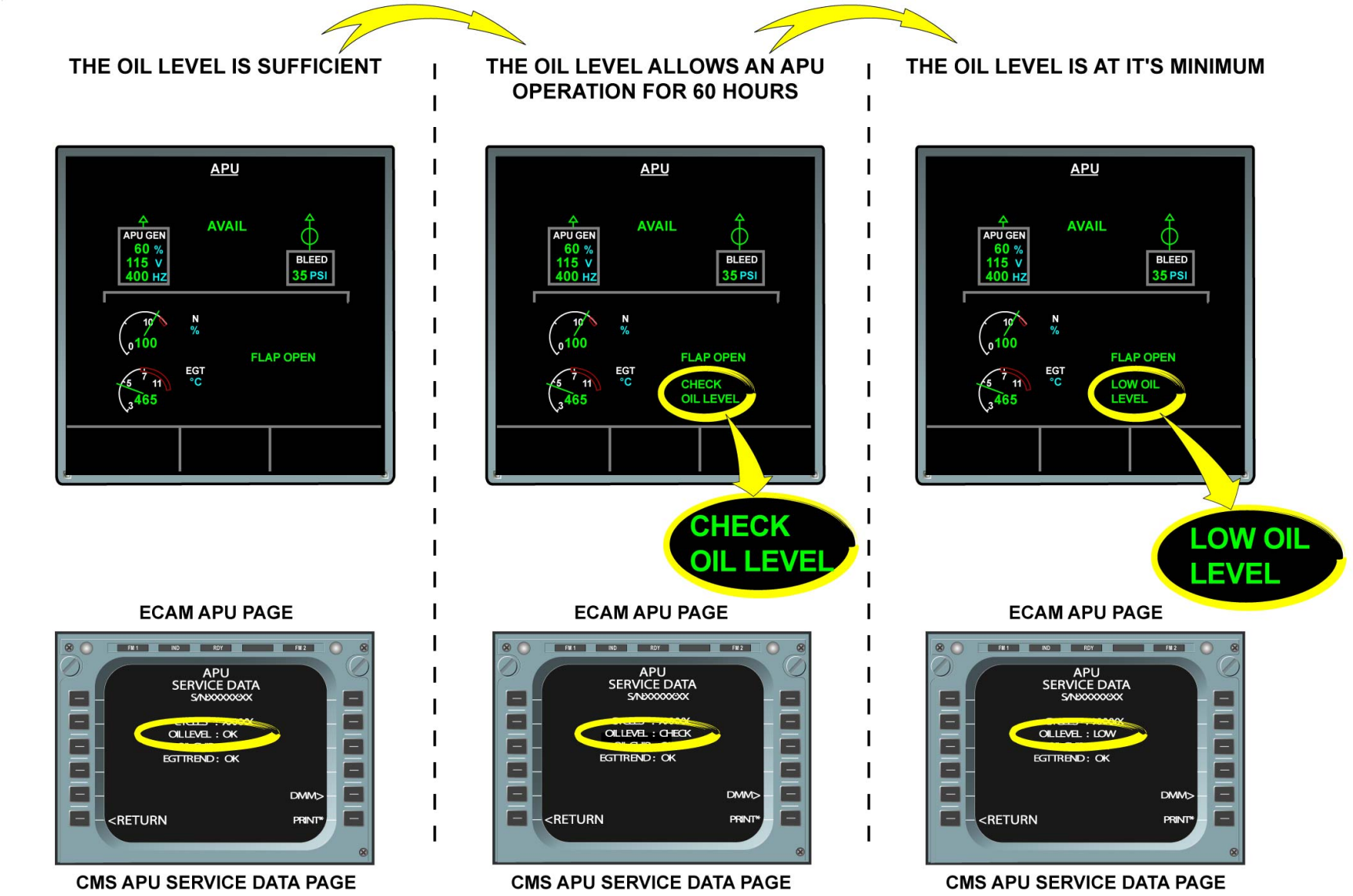
Prior to servicing, shut down the APU and open the APU access doors. Make sure to use the operator-approved oil for servicing (operators may be selected from the approved list). The oil may be serviced by the gravity (most common) or pressure fill procedure (OPTIONAL).

NOTE: To get an accurate oil level indication, do not wait longer than 5-15 minutes after the APU shutdown before checking the APU oil.

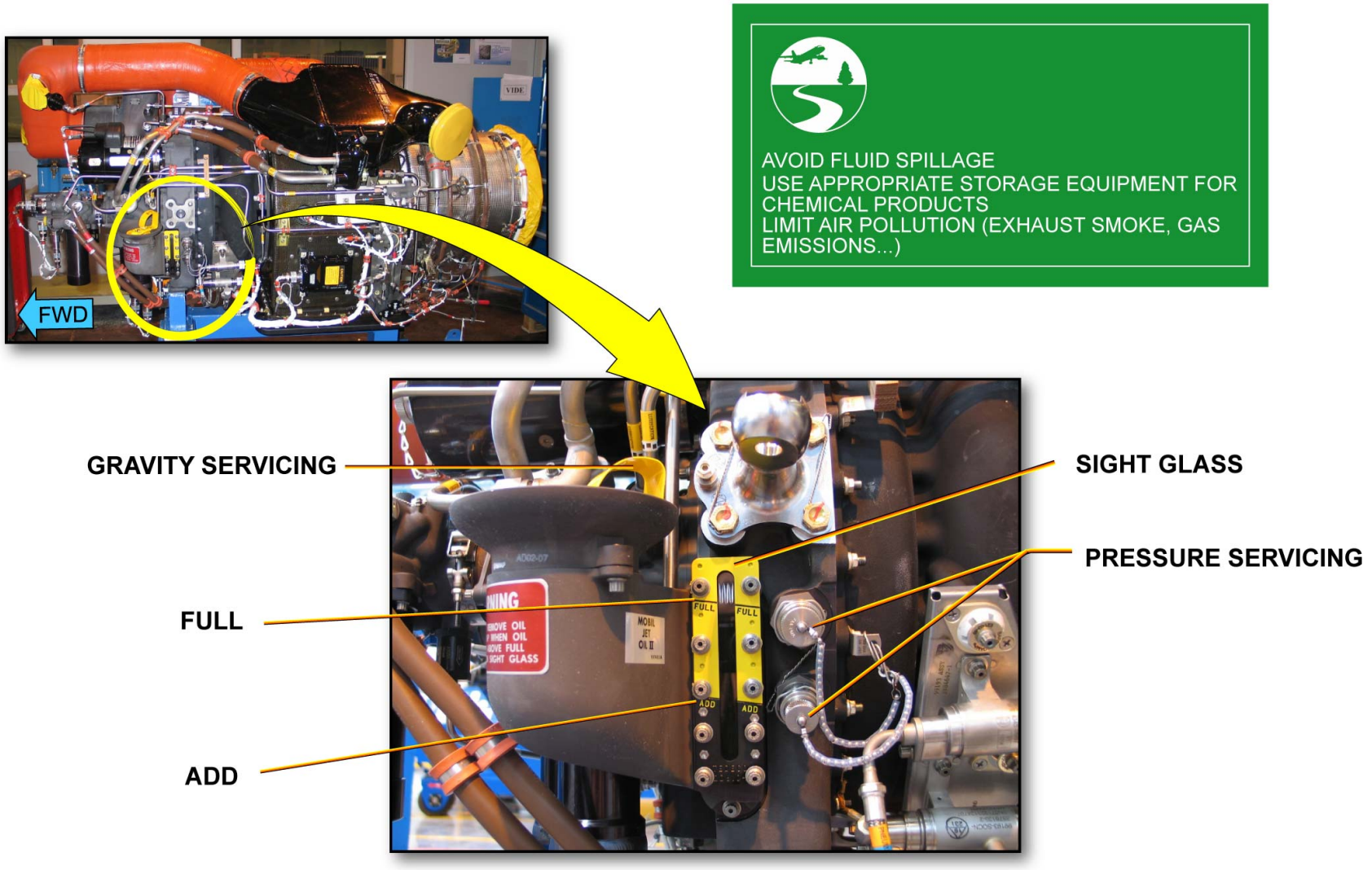
Gravity procedure:
- open the lock and slowly loosen the oil filler cap to release remaining pressure from the oil reservoir,
- check sight glass for level,
- slowly add oil until the level is at the FULL mark on the sight glass,
- close and lock the oil filler cap.

Pressure fill procedure:
- check sight glass for level,
- connect pressure and overfill hoses to the APU gearbox,
- slowly pump oil into the gearbox until the level is at the FULL mark on the sight glass,
- remove pressure and overfill hoses.

GCL13151 - GEHT0M0 - FM49B100000001



SERVICING - APU OIL SERVICING



SERVICING - APU OIL SERVICING

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GCL13151 - GEHT0M0 - FM49B1000000001

APU SYSTEM LINE MAINTENANCE (2)

MEL/DEACTIVATION

In case of an APU inlet actuator failure, the APU may be dispatched per Minimum Equipment List (MEL) with the inlet CLOSED or OPEN. If the inlet is deactivated CLOSED, the APU will not be operational. The APU is only operational with the inlet deactivated OPEN - limited to 10 days as per the MEL. The air inlet flap actuator has a manual drive. In case of failure the manual drive may be used to move the inlet to the required position prior to the deactivation. Access to the actuator is through an access door near the APU inlet on the left hand side of the fuselage. The actuator requires 87 turns of the manual drive for one full travel of the inlet flap.
Deactivation procedure:
- get access to the actuator,
- disconnect the actuator electrical connector from the fixed connector on the frame and install a blanking cap,
- use the manual drive to move the inlet to the required position. Use a torque wrench to avoid damage to the actuator.

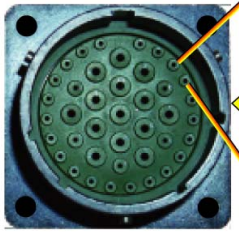
NOTE: Note: If the inlet is deactivated CLOSED, no further action is needed other than to placard the APU inop. If the inlet is deactivated OPEN, the following procedure has to be accomplished.

When the inlet is in the OPEN position, a jumper lead needs to be installed to close the circuit and allow the APU to start. Make a dummy connector and paint it red for easy identification.
Close the access door and make the APU operational test:
- make the BITE test,
- check SERVICE DATA,
- start the APU and check for normal parameters.

GCL13151 - GEHT0M0 - FM49B100000001

ACCESS TO FLAP ACTUATOR

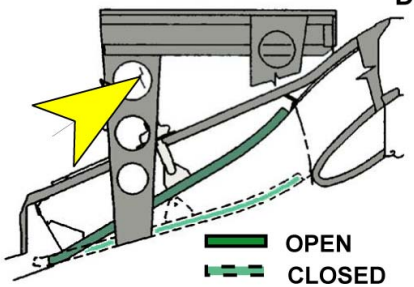
PIN C

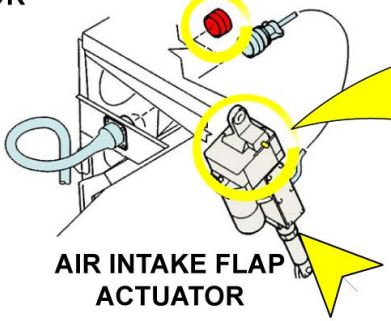


PIN D

DUMMY CONNECTOR

MANUAL OVERRIDE





AIR INTAKE FLAP ACTUATOR

MEL/DEACTIVATION

GCL13151 - GEHT0M0 - FM49B1000000001

APU SYSTEM LINE MAINTENANCE (2)

MAINTENANCE TIPS

BLEEDING OF THE APU FUEL LINE CONTROL AND INDICATING

The APU fuel supply line has a drain and vent valve which lets the line be bled of air after maintenance. The VENT & DRAIN valve is located in the APU compartment in the fuel supply line towards the fuel control.

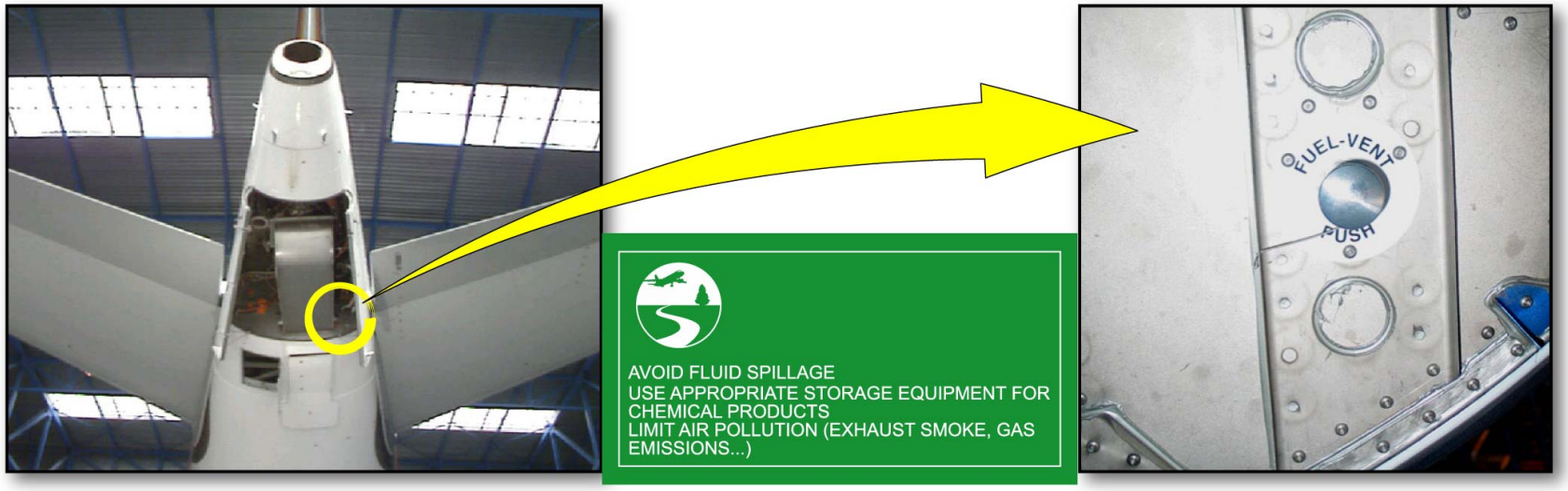
A switch labeled FUEL VENT/PUSH is installed on the APU compartment forward the firewall to let maintenance staff supply positive fuel pressure to the APU from the APU compartment. This switch opens the APU LP valve, the isolation valve and starts the APU fuel pump without the APU Master Switch ON.

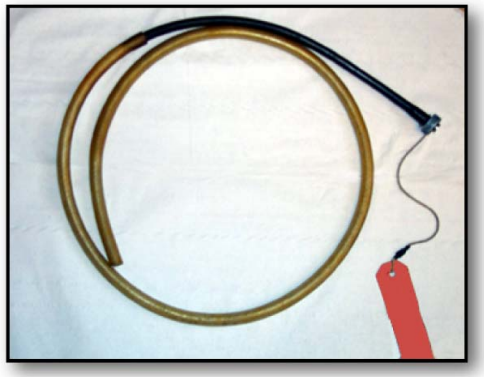
A drain valve adapter tool with a hose is connected to the drain valve.

Procedure:

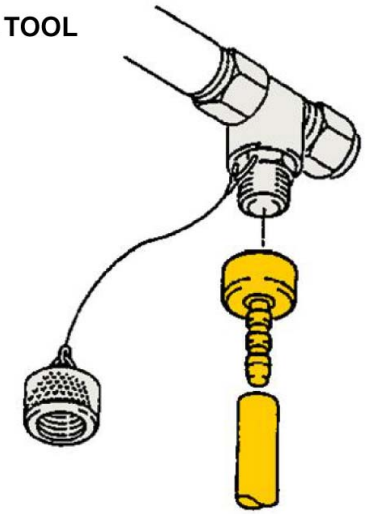
- for safety, install the rig pin in the mechanical input of the Trimmable Horizontal Stabilizer (THS) actuator to prevent movement,
- transfer fuel to the Trim Tank to bleed main FWD/AFT transfer supply line,
- open APU access doors,
- install adaptor tool,
- push and hold the FUEL VENT P/BSW,
- at the APU fuel vent and drain valve, a continuous flow of fuel indicates that the APU fuel pump is operating and the line is bled of air,
- release the FUEL VENT P/BSW - the flow of fuel stops when the APU fuel pump stops running,
- disconnect the adapter tool.

GCL13151 - GEHT0M0 - FM49B100000001

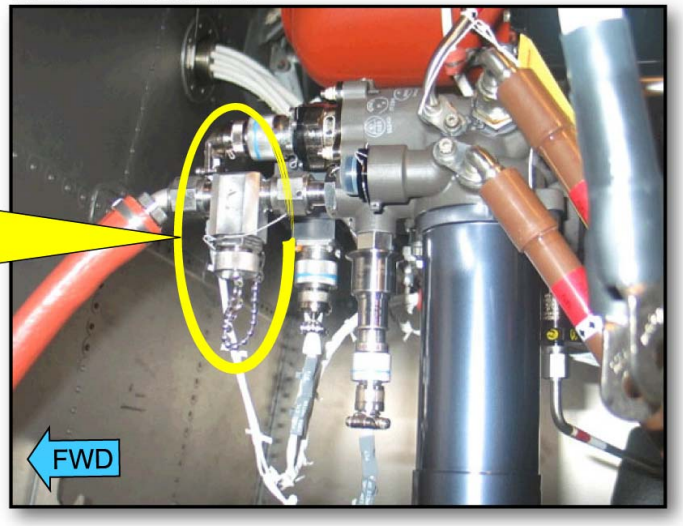




ADAPTOR TOOL



APU FUEL SUPPLY



MAINTENANCE TIPS - BLEEDING OF THE APU FUEL LINE CONTROL AND INDICATING

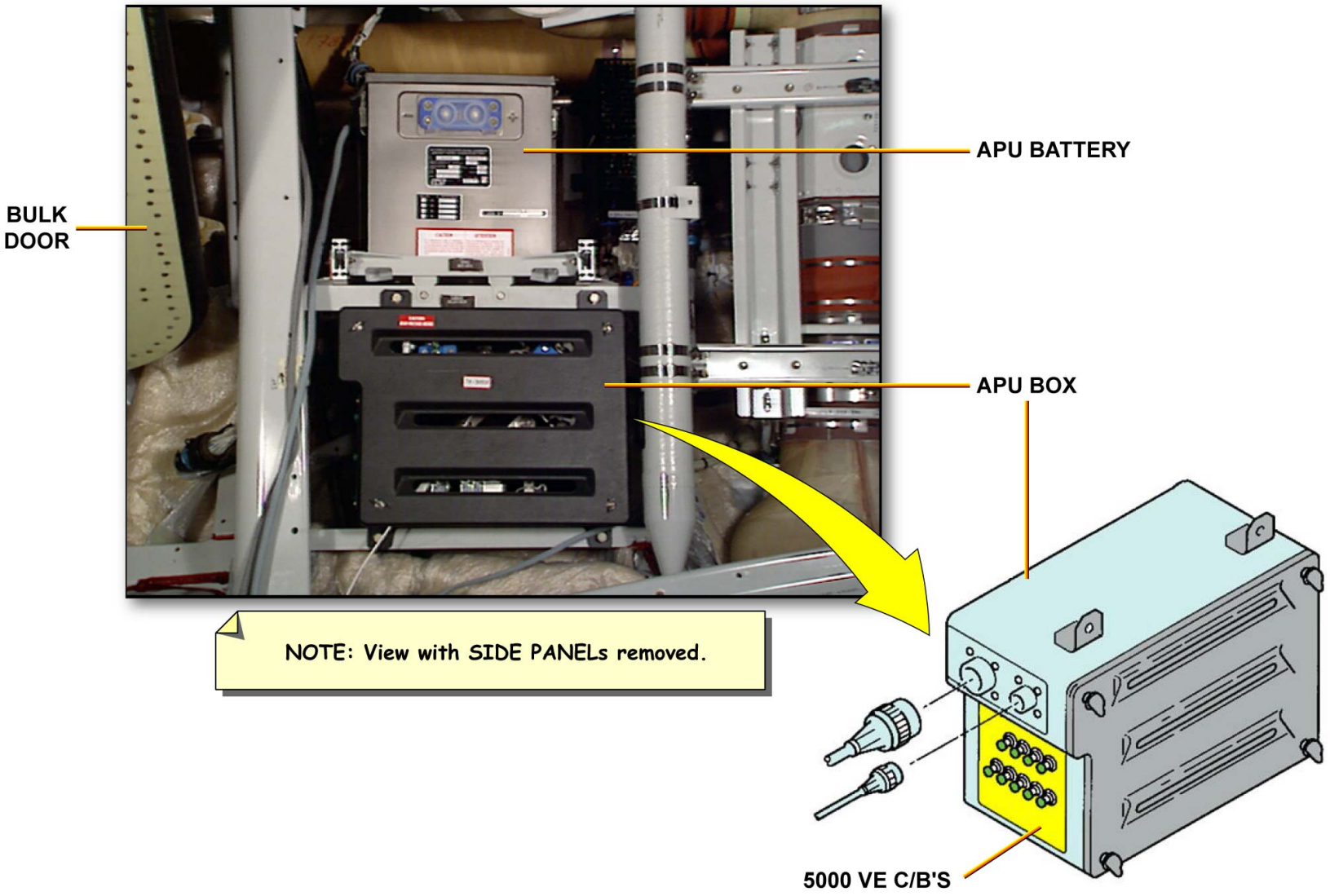
APU SYSTEM LINE MAINTENANCE (2)

MAINTENANCE TIPS (continued)

5000VE APU BOX / CIRCUIT BREAKER PANEL

The APU maintenance procedures in the AMM reference circuit breakers on panel 5000VE (APU CTL, APU MAIN SUPPLY, etc.). The 5000VE panel is located in the APU BOX below the APU battery in the bulk cargo compartment behind the sidewall panel.

GCL13151 - GEHT0M0 - FM49B1000000001



MAINTENANCE TIPS - 5000VE APU BOX / CIRCUIT BREAKER PANEL

APU SYSTEM LINE MAINTENANCE (2)

ENVIRONMENTAL PRECAUTIONS

Do not discharge products such as oil, fuel, solvent, lubricant either in trash bins, soil or into the water network (drains, gutters, rain water, waste water, etc...).
Sort waste fluids and use specific waste disposal containers.
Each product must be stored in an appropriate and specific cabinet or room such as a fire-resistant and sealed cupboard.
Avoid use of the APU if APU BLEED air is not necessary. Turn-off unused ground service equipment (GPU, Air conditioning cart, etc...) if no work is being done or nobody is present on the aircraft.

GCL13151 - GEHT0M0 - FM49B1000000001

STORE PRODUCTS IN APPROPRIATE CONTAINER/CUPBOARD/ROOM

SORT WASTE FLUIDS IN CONTAINERS

AVOID FLUID SPILLAGE
USE APPROPRIATE STORAGE EQUIPMENT FOR CHEMICAL PRODUCTS
LIMIT AIR POLLUTION (EXHAUST SMOKE, GAS EMISSIONS...)

FLUID SPILL CLEANUP KIT

USE SPECIFIC WASTE DISPOSAL CONTAINERS

ENVIRONMENTAL PRECAUTIONS

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